National Weather Service Training Center

Punch Tape Recording Rain Gage

Paper Tape
Description and Quality Control

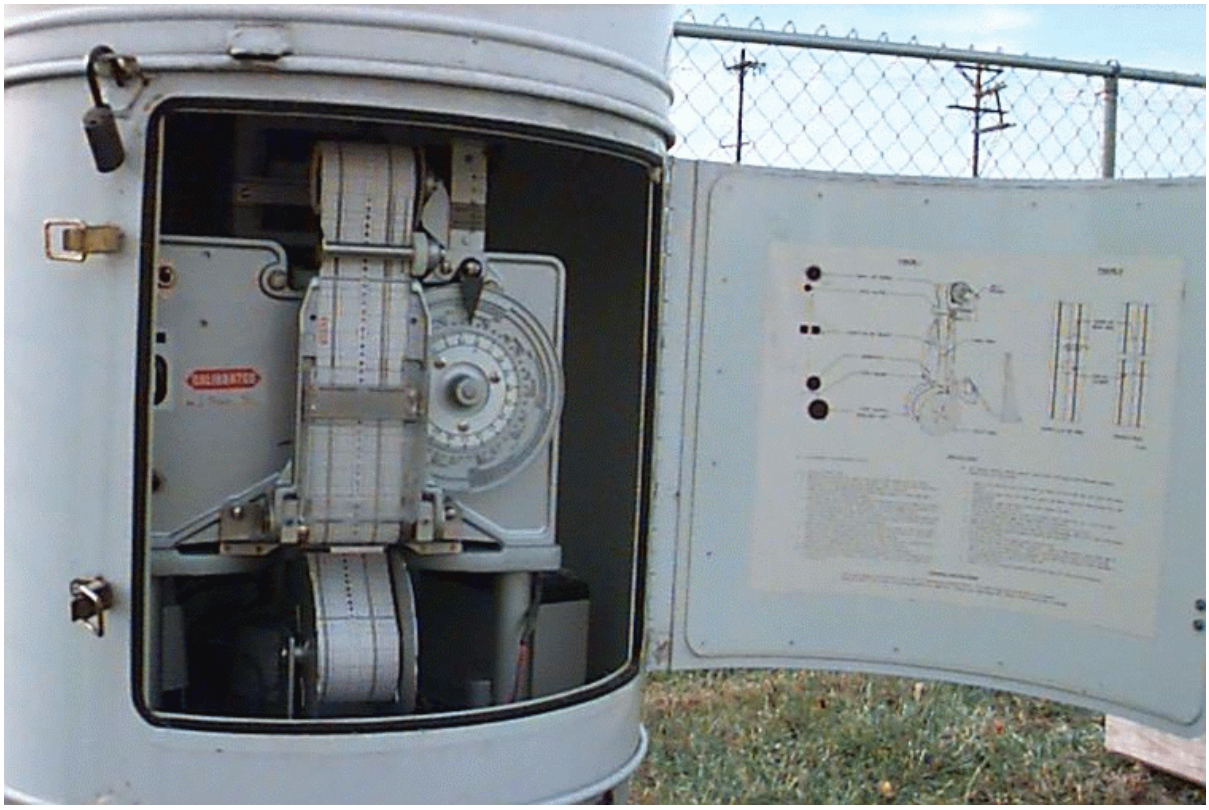
Purpose of the Module

The purpose of this module is two fold: (1) to describe the paper tape used on the Punch Tape Recording Rain Gage that is part of the Cooperative Observing Program of the National Weather Service (NWS); and (2) to describe how to perform quality control of these punch tapes.

Even though there is an image of a paper tape included on this web document, it is strongly recommended that you obtain an actual piece of tape prior to working through this tutorial. It will be easier to examine the tape first hand than to view it on your computer screen.

Our Recommendation: We suggest that you set your browser to 18 point text while viewing this document. Also, image quality will depend upon the quality of your monitor.

Use these links to go directly to specific sections of this module.

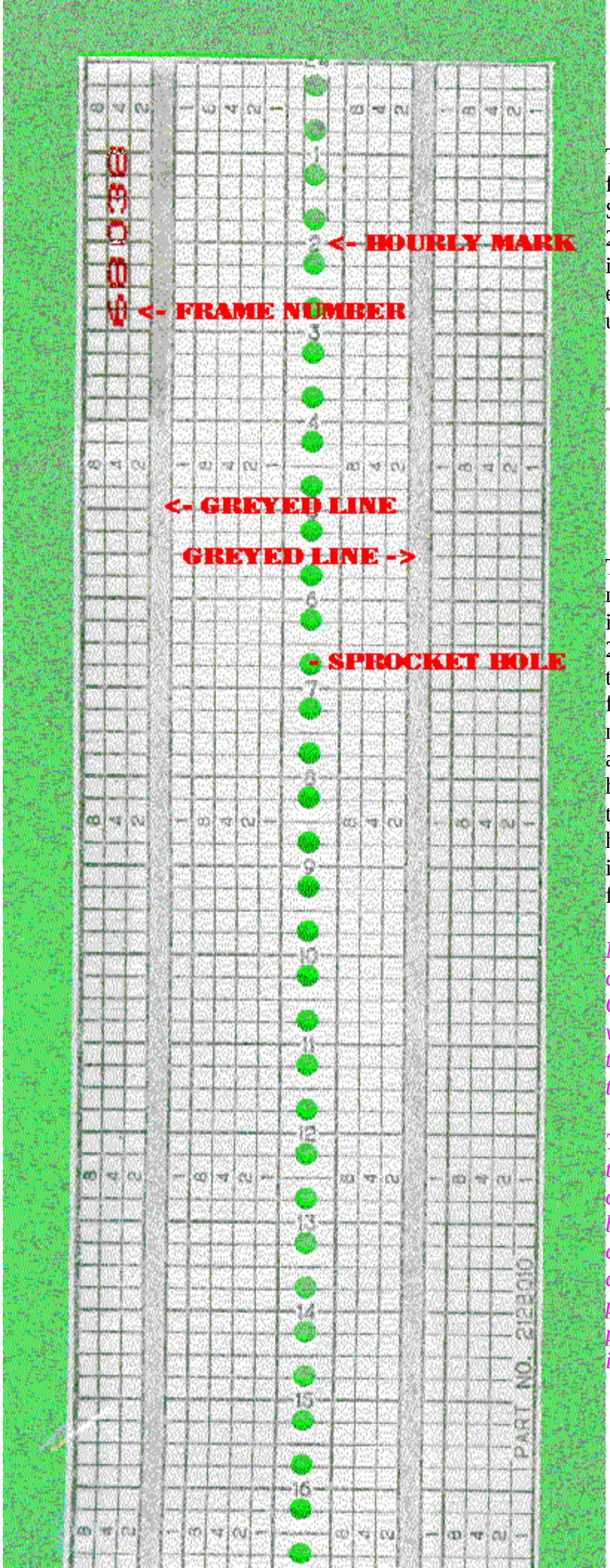


Punch Tape Gage with access door open. The punch tape and punch mechanism inside the casing are visible through the open door.

Description of the Tape

The paper tape used on the NWS punch tape recording rain gage is classified as a strip chart. It is obtained from the NOAA Logistics Supply Center (NLSC) in rolls of 410 feet in length. It contains 450 sequentially numbered, 24 hour frames to accommodate a continuous record of precipitation that collects in the punch tape recording rain gage's bucket. Each individual frame is divided into 24 hours segments, identified from 1 to 24, with each hour divided into 15 minute increments to match the quarter hour punch cycle of this NWS electronic rain gage.

The amount of precipitation collected in the gage's bucket is transmitted to a punching mechanism which then records the amount to the nearest tenth of an inch as a series of holes punched in the tape (hence the name). An electronic timer cycles the gage every 15 minutes, corresponding to the 15 minute divisions on the tape. The series of punched holes run horizontally across the tape and are easily read and interpreted to the precipitation amount measured by the gage.



The paper tape rolls are available from the NLSC using Weather Service stock number D111-2N100. This item does not appear in the *Forms Section* of the equipment catalog, but is found under *Precipitation - Section D.*

Return to the top of the page.

Interpreting the Tape

The interpretation of the tape must begin with an overview of its layout. The tape is divided into 24 uniquely numbered hourly time frames, each just under a foot in length. Sequential frame numbers are printed in **red** just after the beginning of each 24 hour frame. The time printed on the tape is in military format (24-hour clock) where 9 PM is indicated as 21 for the twenty-first hour of the day.

***Note**: This format is sometimes confusing to Cooperative Observers who are not familiar with military time. You may have to explain the 24-hour clock to them during training.*

To avoid confusion and enhance training, it is suggested that the caretaker of the punch tape gage be instructed to perform all tape changes, bucket level adjustments, and time checks prior to noon. This eliminates a potential source of error when installing a new tape.

Note the two greyed lines, approximately 3/8 inch from each edge of the tape, that run the entire length of the tape. These lines are for reference punches which occur at each and every punch cycle regardless of the amount of precipitation in the gage's collection bucket. It is important to note that punches appearing in these greyed areas indicate to the optical tape reader that the gage is operational, even if no data holes are punched, i.e., for reading of 0.0 inches of precipitation.

Decoding the Punched Values: Each of the vertical divisions paralleling the grayed lines form a reference amount for the precipitation accumulated in the collection bucket. Look at the tape with the earliest hour in the 24 hour frame at the top. Each set of four vertical columns represent a digit in the accumulated precipitation amount. Gage measurements range from 0.0 through 19.9 inches, the maximum capacity of the gage.

Four sets of columns labeled 8-4-2-1 represent 4 unique digits in the accumulated precipitation measurement. The digit value is determined from the total punches within each set. In the table below, the "o" represents a punch in the columns which are labeled, from left to right, 8, 4, 2, and 1, respectively.

8	4	2	1	Value
				0
			o	1
		o		2
		o	o	3
	o			4
	o		o	5
	o	o		6
	o	o	o	7
o				8
o			o	9

This table above shows how each digit set would be punched for the numeric values 0 through 9. To obtain the numeric values, add up the column values that are punched. For those of you familiar with binary numbers, the punched columns represent the binary number for the numeric value where a hole equals 1 and no hole equals zero.

Returning to the tape, the first digit set on the right represents the tenths value of the gage's accumulated precipitation; the second set from the right represents whole inches; and the third set from the right represents 10s of inches. The fourth digit set (the left hand set) is not used by the gage because the maximum measurement is 19.9 inches.

As an example, one row on the tape might look like the following table:

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value

			o					o	O	o			o	o	o			o	19.9

The value represented by this row of punches is 19.9 inches of accumulated precipitation. Ignoring the punches for the greyed lines (G) and the sprocket holes (S), the first digit set (on the left) is not punched, as expected. Working from left to right, the second digit set has one punch under "1"; the next digit set has two punches under "8" and "1"; and the third digit set has two punches under "8" and "1". These punches represent a value of 1,9,9 or, when decoded, 19.9 inches, the maximum gage measurement.

The code format for each row is known in the computer world as *binary coded decimal* or *BCD*.

As the precipitation amount increases with time, the accumulated amounts are punched out for each 15 minute time period thereby producing a complete record of precipitation versus time for the gage site. The increase in precipitation from one hour to the next can easily be determined by subtracting the two hourly totals to find the amount of precipitation that has fallen during the period.

Let's see if you understand the decoding process. Decode each of the following and check your answer.

Question 1

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value
			o						O	o			o	o		o	o		

Click on the correct value.

A. 8.6
B. 9.6
C. 9.5
D. 8.7

Question 2

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value
			o					o	O			o	o			o	o	o	

Click on the correct value.

A. 2.7
B. 13.6
C. 12.7
D. 11.8

Question 3

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value
			o						O				o						

Click on the correct value.

A. 0.0
B. 0.5
C. 4.0
D. 10.0

Question 4

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value
			o						O		o		o				o	o	

Click on the correct value.

A. 4.4
B. 4.3
C. 3.2
D. 3.2

Question 5

8	4	2	G	1	8	4	2	1	S	8	4	2	G	1	8	4	2	1	Value
			o						O		o		o	o				o	

Click on the correct value.

A. 4.2
B. 6.1
C. 5.2
D. 5.1

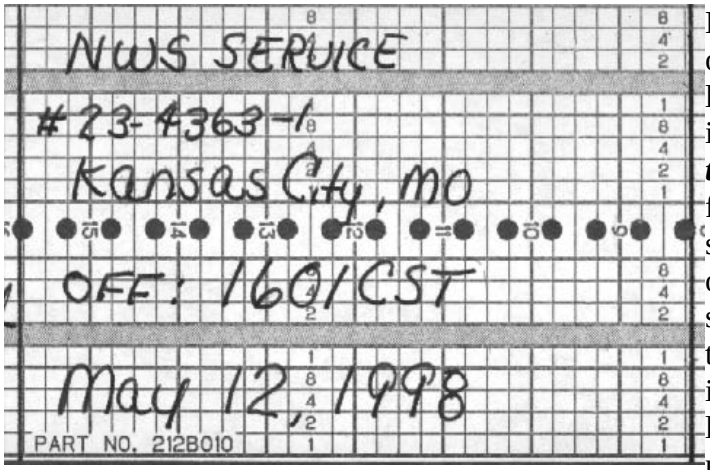
Encoding the Punched Values: The gage mechanisms are designed to translate the precipitation measurement into holes on the punch tape. The gage mechanically reverses the process just described for decoding punch tape codes. Each digit of the gage's accumulated amount is transferred to the code disk and punch block as individual numbers (tenths, whole inches, and tens of inches). For example, punch holes record each digit of a value using the appropriate combination from the 8-4-2-1 digit set as needed to make the required digital value. An

accumulated amount of precipitation in the gage's bucket which corresponds to 15.7 inches would appear punched on the tape as follows.

- For the tenths value is a 7, the gage would show holes punched in the 4, the 2, and the 1 in the first digit set on the right which represents the tenths value. These three numbers add up to 7 which is the desired tenths value.
- For the whole inch value of 5, in the second digit set from the right, the 4 and the 1 would be punched to add up to 5.
- The 10s of inches digit set would show a punch hole in the 1 only.
- Because the maximum capacity of the gage is 19.9, no holes left of the 1 in the 10s of inches digit should be punched other than the grey reference line as discussed earlier.

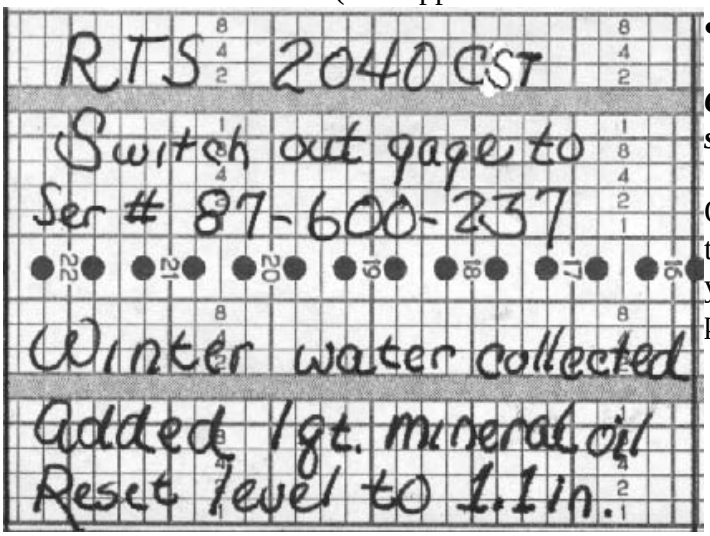
Return to the top of the page.

Service and Annotation of the Tape



Before performing service on any operational punch tape gage at a field location, it is very important to immediately ***draw a line across the top of the punch block*** to serve as time reference for comparison between time of day shown on the tape and time being punched on the tape upon taking the gage out of service. The figure at the left shows how this annotation might appear. It is also important to manually advance the tape leaving an area where the grayed areas are not punched. This gap in punches in the grayed areas will stop the optical reader used by the National Climatic Data Center (NCDC) to decode the tape. It will require the operator of the reader to inspect the tape to determine why it stopped. This break is intentionally introduced at the time of gage service. The information listed below is the minimum information that should be annotated on the tape.

- *Station Number*
- *Station Name* (as it appears on the B-44 for the station)
- *Date and Off Time*

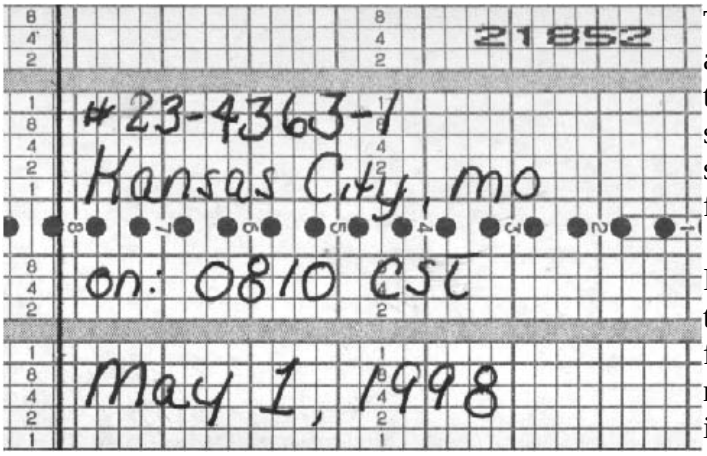


Check your regional instructions for specific annotation requirements.

Once the service has been completed and the gage is ready to return to service (RTS), you should annotate the ***On Time*** plus any pertinent information regarding the service

done on the gage. The figure at the left illustrates what a typical annotation might look like. This annotation should always include any ***Changes in Bucket Level*** from the level the gage was at when it was removed from service for repairs. It is also suggested that the you initial the annotation to facilitate quality control of the tape once received at the NWS office.

When you are ready to place the gage back in service, you must manually advance the tape to where the current local clock time and reference time on the tape at the punch can be synchronized. This advancement will usually result in the loss of at least one frame and corresponding frame number. This loss is referred to as a frame count "offset". This offset must be accounted for when quality control checks are performed for the proper number of frames contained on the tape between ***ON*** frame at the first part of the month to ***OFF*** frame when the tape is removed by the gage caretaker for mailing to the WFO.



The figure at the left shows an example of an annotation that might be made when the tape is changed. The ***ON TIME*** is shown as 0810 CST, MAY 1, 1998. A similar type of annotation would be used for the ***OFF TIME***.

It should be emphasized to the caretaker that the tape should never be removed from the gage prior to the first of the new month. This ensures that the entire month is on the tape for processing at NCDC. Also, any hourly precipitation data sent for days after the 1st of a month is stored in NCDC's computers so that subsequent data from the next tape will meld correctly to make a complete month.

Return to the top of the page.

Punch Tape Quality Control

Quality Control on the paper tape at the WFO level is a very important function. It directly impacts on the credibility of data from the NWS's primary Recording Rain Gage Network. Data from these tapes are currently the sole data source used to compile the Nation's Hourly Precipitation Data.

The quality control process associated with the punch tapes has several steps. First, check to ensure that all tapes from Cooperative Stations assigned to your WFO are received by a predetermined date. Late tapes should be aggressively pursued. The deadline for tape receipt at your office is determined by Regional Headquarters and local WFO policies in concert with input from the National Climatic Data Center.

Upon arrival, check each incoming tape against its mailing container or envelope to ensure proper identification. Occasionally tapes will arrive without identification at either the ***ON*** or ***OFF*** frames. In such cases, the identification of these tapes can generally be determined from the mailing container or envelope.

After initial check in and tape identification, each tape should be checked for complete annotation. The outer end of the tape roll contains the ***OFF*** data frame. Conversely, the innermost segment of the tape roll contains the ***ON*** data frame. Cooperative Weather Observers should be trained to always fully annotate their tapes at both ***ON*** and ***OFF*** ends of the tape. These annotations should include:

- Station Number *(as on the current B-44)*
- Station Index Number *(as on the current B-44)*
- Date *(suggested date format: DD MON YYYY, i.e., 14 MAY 1999)*
- ON/OFF Time *(Local Time Zone and Standard/Daylight Saving Time Identification)*
- Time Reference Line Drawn across Top of the Punch Block *(This allows for comparison of Local ON or OFF time to tape time reference lines.)*
- Changes made to Bucket Level *(if changed between tape ON and OFF frames)*
- 15 to 18 inches of blank tape before the first data punch *(This allows space for threading of the tape on the Mitron reader at NCDC.)*

Each station's tape must be completely unrolled to check the ***ON*** annotation.

Part of the initial QC check is to ensure that observers do not remove tapes prior to the first of the new month. This ensures that an entire month is covered through midnight on the last day of the month. If additional data for the first few days of the current month are contained on the tape, they are also processed and stored at NCDC. When the next tape arrives from the station, these data are then combined to make a complete month's worth of data for the current month.

In addition to checking for proper identification, each tape must be checked for proper frame count. Each day should equal one frame. As each 24 hour frame on the tape is sequentially numbered, a quick subtraction of the ***ON*** frame number from the ***OFF*** frame number will reveal the total number of frames, or days, on the roll. Keep in mind that a tape that started on the 1st day of a 31 day month and taken off on the first day of the following month should contain 32 frames. It is important to scan the full tape for ***frame offsets***. As described above, frame offsets can occur when service is performed during the data month and the tape was manually advanced to document service performed on a gage. This area of tape with no punches in the grey reference lines will physically stop the optical reader at the NCDC. This stoppage is a must as the person processing the tape needs to know details related to gage service.

Winterization of a gage, which changes the bucket level, is a prime example of information needed by the NCDC tape processing staff. Any change to the bucket reading made by either the observer or the NWS must be noted on the tape in order to allow the tape reader to be reset to the new value so that erroneous precipitation is not generated. Any changes to the bucket level must also include the manual advancement of the tape so that the tape reader at NCDC stops. The number of frames manually advanced for service (frame offsets) must be added to the subtraction

frame total (from the ***ON*** frame to the ***OFF*** frame) to come up with the correct frame count for the entire tape.

Physical damage to the tape must also be evaluated. Some problems are obvious upon opening the mailing container. The tape may be too short or inordinately long. As the tape is unwound to check for frame offsets, it should also be scanned for problems. Skipping and stripping are the most obvious problems. When a tape shows signs of physical damage, you must attempt to salvage useable portions of the tape and forward them to NCDC for partial processing. Also, an attempt must be made to determine the cause of the tape damage to assist in planning gage repairs.

One of the less obvious checks that must be made on incoming tapes is to ensure that tape punch values change from time to time when rain or snow occurs during the month. Initially, compare the value of the last punch for the month to the value for the first punch. There should be an increase as the gage records precipitation during the month. If the first and last values are the same, there may be a gage malfunction. If this occurs, it is probable that the lower drive cable is broken or the bucket's drain tube has become detached from the bucket. In either case, a service call is in order. A telephone call to the gage caretaker will often help in diagnosing the problem and planning repairs.

Another routine check of tapes is to ensure that the 10s punch is operational. When unrolling the tape, follow the increase in punch values from the 1st of the month until the bucket value goes over 10 inches. At this point, it is imperative to ensure that the 10s punch value is punched. If the 10s punch is missing when it obviously should be punched, it is probable that the gage timing is incorrect due to improper wrapping of the lower drive cable. Correction of this problem will require a service call to reinstall the lower drive cable. Although often assumed, it is a rare occasion that the missing 10s punch is caused by the punch itself being missing from the punch block.

Return to the top of the page.

Disposition of Tapes

Once the punch tapes received at your station have undergone local quality control and evaluation, the tapes are sent NCDC for processing. It is suggested that copies of QC logs be included in the box to assist NCDC during processing. This log should indicate any tapes discarded at the WFO. The mailing/shipping method is left to Regional and/or Local WFO policies. A method providing a return receipt is advisable.

Return to the top of the page.

Gage Service to Repair Tape Problems

It is imperative that the repair of punch tape gages always include checking and making ***critical adjustments*** to the gage. Most tape problems can be traced back to improper critical adjustments. It is also a good idea to install a new roll of tape on the gage if less than 45 days remain on the supply reel. A quick check of the tape supply reel will show the number of days remaining on the tape. A good ***Preventative Maintenance*** (PM) program for the gages in your network, including Critical Adjustments, is an important aspect of reducing staff hours expended on Punch Tape Gage emergency repair visits. Tape quality will dramatically increase and problems will show a proportionate decrease if PM is routinely done.

Return to the top of the page.

Additional Review Questions

Question 6

Each frame of the punch tape covers a period of:

A. 15 minutes
B. 1 hour
C. 24 hours
D. 450 days

Question 7

True or False: When the gage is active, there will always be a hole in the greyed lines.

A. True
B. False

Question 8

An annotation should be made on the tape whenever:

A. The gage is taken off line for service.
B. The punch tape is changed.
C. The gage is returned to service after being serviced.
D. All of the above.

Question 9

What is the minimum amount of information that should be included on a punch tape annotation?

Check your answer here.

Question 10

List the eight quality control checks described in this module.

Check your answer here.

Return to the top of the page.

Answers to Questions from Punch Tape Recording Rain Gage

1. **B**
2. **C**
3. **A**
4. **B**
5. **D**
6. **C**
7. **A**
8. **D**

9. What is the minimum amount of information that should be included on a punch tape annotation?

The minimum amount of information that should be annotated on a punch tape is:

1. **Station Number**
2. **Station Name (as it appears on the B-44 for the station)**
3. **Date and Off/On Time**

10. List the eight quality control checks described in this module.

These quality control checks are:

1. **Check to ensure that all tapes from Cooperative Stations assigned to your WFO are received by a predetermined date.**
2. **Check each incoming tape against its mailing container or envelop to ensure proper identification.**
3. **Each tape should be checked for complete annotation.**
4. **Ensure that observers do not remove tapes prior to the first of the new month.**
5. **Each tape must be checked for proper frame count.**
6. **Physical damage to the tape must be evaluated.**
7. **Ensure that tape punch values change from time to time when rain or snow occurs during the month.**
8. **Ensure that the 10s punch is operational.**