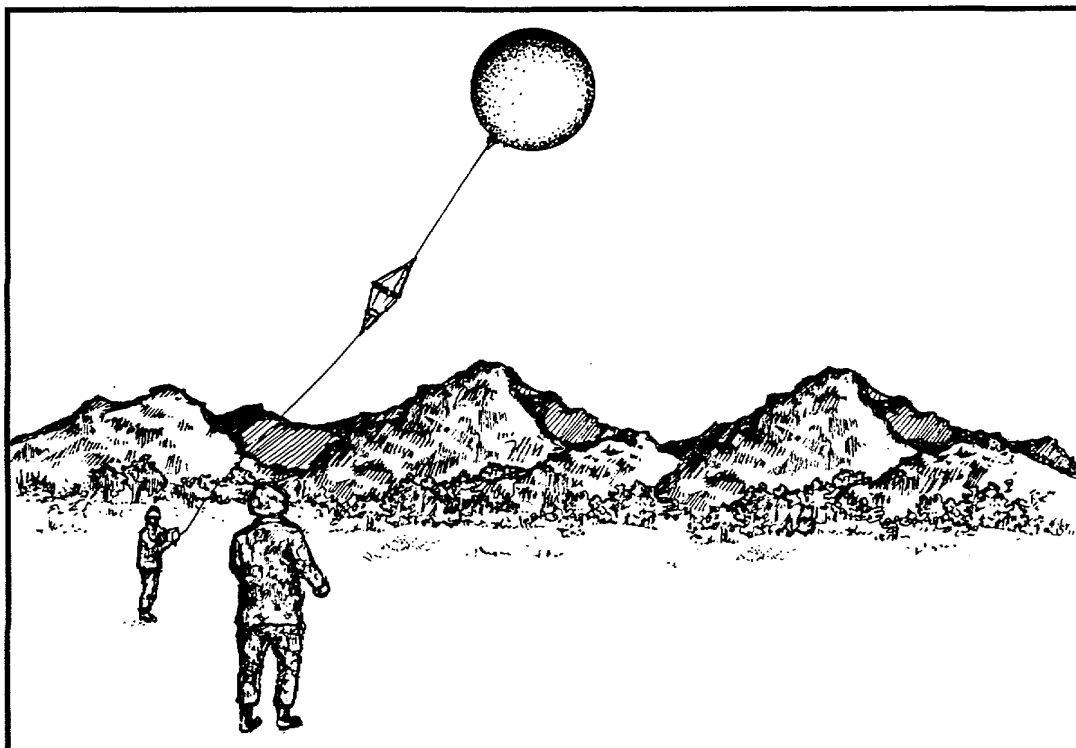

US ARMY FIELD ARTILLERY SCHOOL

**ADVANCED
METEOROLOGICAL PROCEDURES**



**THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM**



FIELD ARTILLERY METEOROLOGICAL CREW MEMBER
MOS 93F SKILL LEVEL 4

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ADVANCED METEOROLOGICAL PROCEDURES

SUBCOURSE FA6045

US Army Field Artillery School
Fort Sill, Oklahoma

Three Credit Hours

GENERAL

This subcourse is designed to train the skills necessary for performing tasks related to performing advanced meteorological procedures. This subcourse is presented in two lessons, each corresponding to a terminal objective supporting the following soldiers manual tasks:

LESSON 1: Evaluate Weather Conditions

TASK NO: 061-303-4016

TASK: Determine and identify the passage of warm and cold fronts.

CONDITIONS: A change of weather has occurred during the sounding schedule.

STANDARDS: You must identify frontal passages and take necessary actions to continue the sounding schedule IAW FM 6-15.

TASK NO: 061-303-4017

TASK: Identify the types and heights of clouds.

CONDITIONS: You will be given a stopwatch or timer, an inflated pilot balloon, and inflation equipment.

STANDARDS: Identify the type and height of clouds.

LESSON 2: Perform Quality Control of Meteorological Forms, Charts, and Records.

TASK NO: 061-303-4004

TASK: Perform quality control of meteorological forms, charts, and records.

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CONDITIONS: You will be given the forms, charts, and records of a completed rawinsonde observation.

STANDARDS: You must check all evaluations, computations, plots, and recordings to determine errors and inaccuracies.

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GRADING AND CERTIFICATION INSTRUCTIONS

Instructions to the student. This subcourse has an examination that is a performance-based, multiple-choice test covering two lessons. You must score a minimum of 75 percent on this test to meet the objectives of the subcourse.

Credit hours. Three credit hours will be awarded for successful completion of the subcourse.

Lesson 1

EVALUATE WEATHER CONDITIONS

OBJECTIVE

Upon completion of this lesson, you will be able to evaluate weather conditions so that you may schedule meteorological (met) soundings at logical times.

REFERENCES

This lesson is based on FM 6-15 and other materials approved for US Army field artillery instruction; however, development and progress render the text continually subject to change. Therefore, base your examination answers on material presented in this lesson rather than on individual or unit experience.

1. INTRODUCTION. A substantial change in atmospheric conditions will have a substantial effect on the data in a met message which, in turn, is used to aim artillery projectiles. When far-reaching atmospheric changes occur, as in frontal passages, they will provide distinctive weather and cloud patterns. The sounding schedule for mission support is dictated by the predictable movement of the sun in what is called the "meteorological day." When the natural fluctuation in local temperature, density, and wind is interrupted by frontal invasion, the normal flight schedule must be changed. The met section chief must be able to recognize when frontal invasion occurs and to adjust the flight schedule accordingly. If he can identify the weather conditions and cloud types associated with the basic types of fronts, he will know when a sounding needs to be updated and firing batteries will receive better met support.
2. CLOUDS. Clouds are defined as visible condensed moisture, consisting of water or ice crystals in the atmosphere above the surface of the earth. Properties necessary for formation of clouds are moisture, a cooling process, and condensation nuclei. Condensation nuclei are atmospheric impurities such as soot, dust, sea salt, and pollutants. A detailed description of clouds appears in subcourse FA6051, Introduction to Field Artillery Meteorology, which is a prerequisite subcourse. You should review that portion of that subcourse now.
3. MEASURING CLOUD HEIGHTS. There are several apparatus used to measure the heights of clouds. Radar can measure the distance to the base of a dense cloud. A ceilometer can be used. It displays a strong beam of light on a cloud base. Then from a known distance from the light source, you can use a clinometer to sight on the spot of light. Through triangulation, you can determine the height of the cloud. The height of a low-level cumulus cloud can be measured simply with a psychrometer and a set of dew point tables, but that is not so reliable. In the field artillery, the height of clouds is determined with equipment available to the section. The theodolite is set up, leveled, and oriented. A 100-gram balloon is inflated, weighed off, and released. At the moment of release, a stopwatch is started and the balloon is tracked with the theodolite. When the balloon disappears from view in a cloud, the stopwatch is stopped. Because the 100-gram balloon has a known rate of rise (about 300 meters per minute), the altitude of the base of the cloud is determined by multiplying 300 by the time when the balloon disappeared. As an example, if the balloon disappeared in 5 minutes, the cloud was 1,500 meters high ($300 \times 5 = 1500$). This information is included in target acquisition messages and limited surface

observation messages. It also is useful information to determine if the measured cloud is in the low, middle, or high classification.

4. **FRONTS.** Fronts are transition zones between air masses that have different densities. The density of air is primarily controlled by the temperature of the air; therefore, fronts in temperate zones usually form between tropical and polar air masses.

a. Cold front. A cold front is the leading edge of an advancing mass of cold air. As the cold air advances, it replaces warm air and tends to accelerate because cold air is dense and heavy. The frontal slope becomes steeper, or more vertical, near the surface because of friction of the terrain. This causes warm air ahead of the front to be pushed aloft abruptly. When the warm air ahead of the front is moist and unstable, the clouds are predominantly cumuliform. With typical cold fronts, a line of thunderstorms develops along the surface of the front and may extend for hundreds of miles. The frontal weather band varies in width from 5 to 80 miles. The degree of instability, the moisture content of the warm air, and the speed and slope of the frontal surface determines the intensity and type of frontal clouds.

(1) Temperature change. Cold fronts bring warm temperatures ahead of the front in southwesterly winds and cold air behind the front in northwesterly winds.

(2) Cold front motion. Cold fronts generally move from northwest to southeast and are faster than all other fronts.

(3) Identification. Cold fronts are identified by a solid blue line on colored weather maps or by a series of black triangles along a black line on noncolored weather maps. The cold front moves in the direction to which the triangles are pointing (Figure 1).

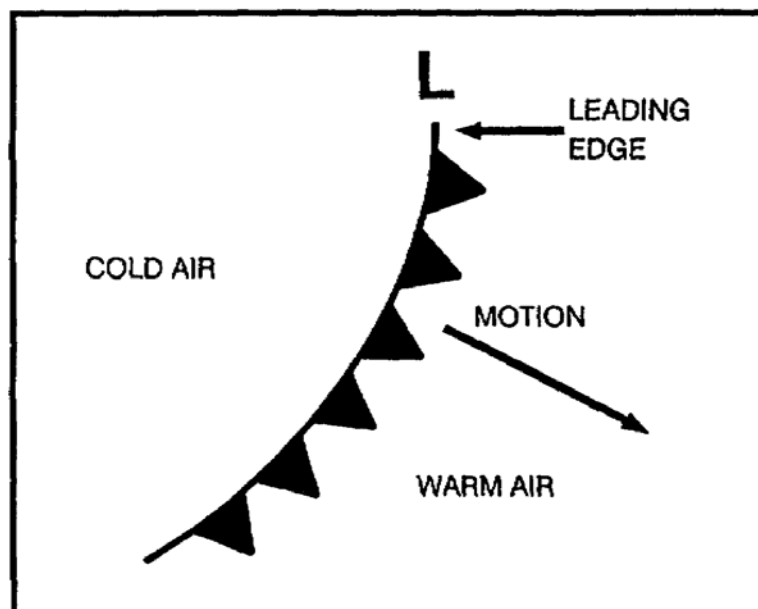


Figure 1. Cold front.

b. Warm front. In warm fronts, surface-cool-modified (polar) air retreats northward on the forward (east) side of cyclones in the northern hemisphere. The air mass boundary formed between the trailing edge of the retreating mass of cool air and the warm air mass moving in to replace it is a warm front. Warm fronts lie in troughs of low pressure, and they normally extend eastward from a center of low pressure.

(1) Wind shift. The wind in the cool polar air ahead of the typical warm front is from the southeast, while the wind in the warm section behind the front is from the southwest.

(2) Temperature change. As a surface warm front passes a location, the temperature increases from a few degrees to more than 20° Fahrenheit (F).

(3) Cloud formation. The lighter advancing warm air glides up over the retreating wedge of cold air. If the warm air is lifted above the condensation level, clouds will form in the warm air above the frontal surface. When the warm air is moist and stable, the clouds will be stratiform, ranging from thick stratiform near the surface front to high cirrus as far as 1,000 miles ahead of the front. As the rain evaporates in the thin wedge of cold air, this air becomes saturated and produces an area of low status, or fog about 200 miles wide ahead of the surface front.

(4) Warm front motion. Warm fronts usually move from southwest to northeast at an average speed of 10 knots.

(5) Identification. Warm fronts are identified by solid red lines on colored maps and by series of black semicircles along a black line on a noncolored map. The warm front moves in the direction to which the semicircles are pointing (Figure 2).

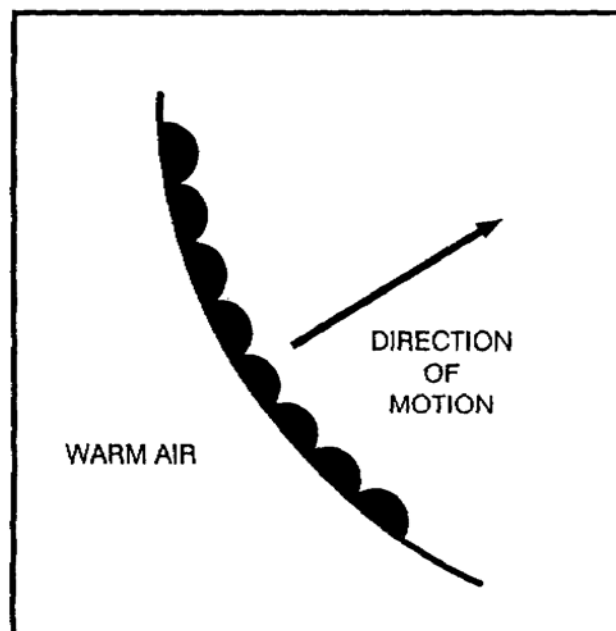


Figure 2. Warm front.

c. Stationary front. A stationary front is a meeting of cold and warm air masses with neither air mass advancing. Although there is no movement of the surface position of the true stationary front, an upglide of air can occur along the frontal slope. Fronts moving less than 5 knots are called either quasi-stationary or stationary. The warm air rising over the stationary frontal surface will cool adiabatically. If the air is lifted above the condensation level, clouds will form above the frontal surface. Open waves may occur along a stationary front. A stationary front is depicted as alternating triangles and semicircles on opposite sides of the frontal line on a black and white weather map (Figure 3).

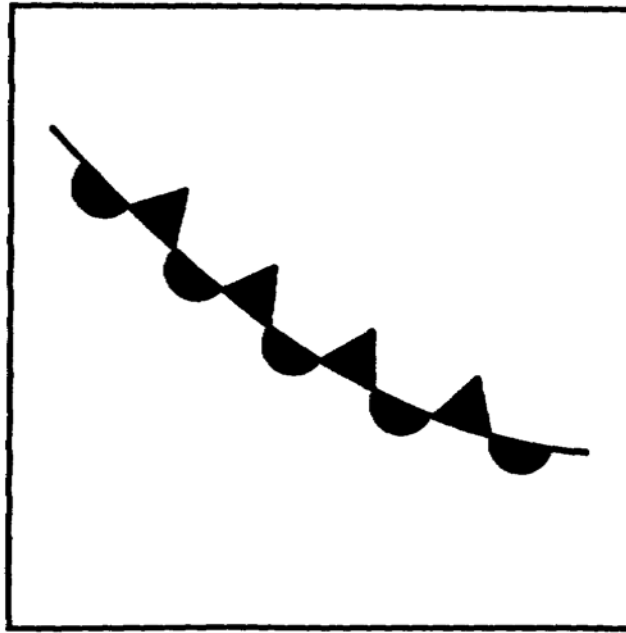


Figure 3. Stationary front.

d. Occluded front. An occluded front occurs when a cold front moves eastward more rapidly than a warm front. The cold front first overtakes the warm front at the crest of an open wave, with the wave gradually closing. As this closing of the warm and cold fronts occurs, the air of the warm sector is lifted off the surface, because the cold air has passed under the warm air and has met with other cool air beyond the warm front. This is called the occlusion process. The portion of the surface front, where the cold front has overtaken the warm front, is called a surface occluded front. An occluded front is depicted on a weather map as alternating semicircles and triangles on the same side of the frontal line (Figure 4).

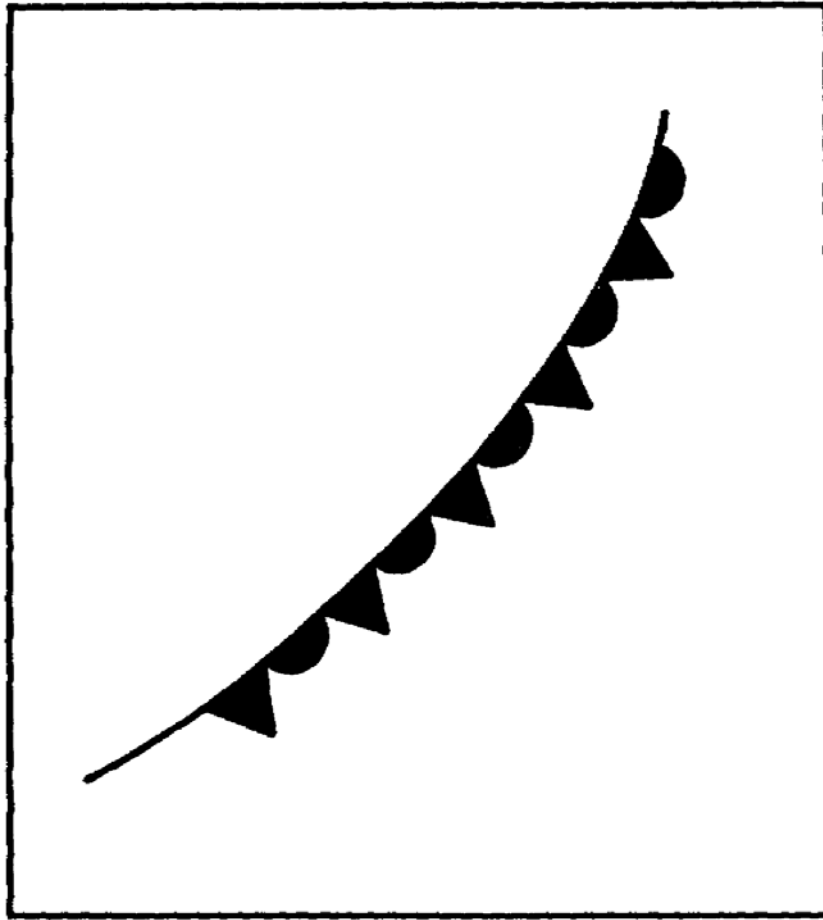


Figure 4. Occluded front.

e. Effects of frontal systems on field artillery. When a front passes through an area of artillery fire, the ballistic met data the firing unit had been using to that point becomes invalid. Changes in every aspect will have occurred. Wind speed, wind direction, air temperature, air density and air pressure at any given altitude will be different. If artillery firing is continued with the prefront met data, the firing will be inaccurate. A met section chief must be able to recognize the passing of a front by cloud formation change and wind and temperature changes at surface. It is his responsibility to advise artillery firing units of the passing of a front. His signal responsibility is to sound the atmosphere immediately following the passing of a front, despite the sounding schedule, and provide the artillery with new data as soon as possible.

PRACTICE EXERCISES:

Complete the following exercises by circling T for true or F for false, circling the letter preceding the correct answer, or filling in the blanks, as appropriate. Be sure to complete the practice exercises as they appear. They are "building blocks" and will help you complete the rest of the subcourse successfully. The answers follow the last exercise and are separated by rows of slashes (/////). If any of your answers are incorrect, restudy the appropriate part of the subcourse before you continue.

1. Which of the following is not a condensation nuclei?
 - a. soot
 - b. dust
 - c. salt
 - d. snow
2. A 100-gram balloon disappears into the clouds at 3.6 minutes. What is the height of the clouds?
 - a. 360
 - b. 720
 - c. 1080
3. What causes a frontal slope of a cold front to be more vertical?
 - a. friction
 - b. wind speed
 - c. warm air
4. What is the average speed, in knots, of a warm front?
 - a. 10
 - b. 20
 - c. 30
5. Your section has completed a sounding at 1000 hours. The next scheduled sounding is 1400 hours. A frontal passage is detected at 1130 hours. What is your responsibility?
 - a. Conduct the 1400 hours sounding on schedule.
 - b. Rebroadcast the 1000 hours sounding at 1200 hours.
 - c. Conduct a sounding immediately.
 - d. Conduct the 1400 hours sounding at 1300 hours.

ANSWERS:

- ////////////////////////////////////

5. SUMMARY. A met section chief must be able to measure the heights of clouds because that information is required on certain messages. He must be able to recognize types of clouds because they indicate types of fronts. Finally, he must be able to recognize the passing of a front and take appropriate action to ensure continuing accurate met data for the field artillery.

Lesson 2
PERFORM QUALITY CONTROL OF METEOROLOGICAL
FORMS, CHARTS, AND RECORDS

OBJECTIVE

Upon completion of this lesson, you will be able to perform quality control on met forms, charts, and records to ensure that all data are correct. This procedure also will provide a basis for corrective unit training.

REFERENCES

This lesson is based on FM 6-15 and other materials approved for US Army field artillery instruction; however, development and progress render the text continually subject to change. Therefore, base your examination answers on material presented in this lesson rather than on individual or unit experience.

6. INTRODUCTION. As chief of a met section, it is imperative that you process data quality control techniques to ensure the data that are transmitted to the using units are timely and valid. This is especially true when using the manual method of met message production because there are numerous complex charts, forms, and plotted information that must be checked before you can be sure that the met messages are accurate. To be able to check all of this information, you must develop a quality control plan that is complete, yet not so cumbersome that delay of message transmission will result. Look at the back of this subcourse for the charts and forms from a typical manual flight. Use the checklist below, and see if you can find any errors.

a. Radiosonde recorder record checklist.

- (1) Has the radiosonde recorder linearity calibration chart been inscribed on the record?
- (2) Have all pertinent data concerning the surface check been recorded on the record in accordance with FM 6-15?
- (3) Is the surface check valid?
- (4) Has the reference-temperature-humidity check been performed? Is it correct?
- (5) Have all pertinent data concerning the release been recorded on the record?
- (6) Have all significant and mandatory levels been selected?
- (7) Have all reference traces been identified and numbered?
- (8) Was the release contact correct? If not, has it been corrected?
- (9) Have the temperature recorder division values been corrected for the linearity calibration and frequency drift at all levels? Are the evaluations correct?

- (10) Have all low references been corrected for frequency drift?
- (11) Have the correct numbers been evaluated correctly?
- (12) Has the record been evaluated in accordance with FM 6-15?

b. DA Form 4197 (Radiosonde Data) checklist.

- (1) Have all pertinent data been recorded on the form?
- (2) Have all significant and mandatory levels evaluated on the record been recorded on the form?
- (3) Have all recorder divisions been correctly converted to temperature and or humidity?
- (4) Have all contact numbers been correctly converted to millibars?
- (5) Have all times for each level been correctly evaluated (OL-192 only) ?

c. Chart ML-574 checklist.

- (1) Have all significant levels been plotted? Have they been plotted correctly?
- (2) Have all zones been identified correctly?
- (3) Have the zone midpoint densities been evaluated accurately?
- (4) Have the zone midpoint temperatures been evaluated accurately?
- (5) Are the replots from one leg to another correct?
- (6) Has the pressure at the top of each zone been evaluated accurately?

d. DA Form 4450 (Ballistic Density or Temperature) checklist.

(1) Ballistic temperature.

- (a) Have all the pertinent data been recorded on the form?
- (b) Have the midpoint temperatures been transferred from the ML-574 chart correctly?
- (c) Has the temperature in degrees Celsius for each zone been correctly converted to percent of standard?

- (d) Are the weighted values for each zone correct?
- (e) Have the weighted values been added correctly?

(2) Ballistic density.

- (a) Have all pertinent data been recorded on the form?
- (b) Have the midpoint densities in grams per cubic meter been correctly transferred from the ML-574 chart?
- (c) Are the weighted values for each zone correct?
- (d) Have the weighted values been added correctly?
- (e) Has the density in grams per cubic meter (g/m^3) for each zone been correctly converted to percent of standard?

e. DA Form 3959 (Pressure-Time Chart) checklist.

- (1) Have all pertinent data been recorded on the form?
- (2) Have all pressures and times been plotted correctly on the chart?
- (3) If an error occurred at the release contact, was an appropriate correction made on the chart?
- (4) Is the evaluation for each zone correct?

f. DA Form 4469 (Rawin Computation) checklist.

- (1) Have all pertinent data been recorded on the form?
- (2) Are all zone heights in column (1) correct?
- (3) Has the pressure at the top of each zone been transferred from the ML-574 chart correctly?
- (4) Has the time at the top of each zone been transferred correctly for DA Form 3959?
- (5) Was a correction to the angular data required because of the optical-electrical bearing check? If so, has this correction been applied to all data?
- (6) Are the horizontal distances correct?
- (7) Have the data for zone winds been plotted correctly?
- (8) Have the zone wind directions been read correctly?
- (9) Were the travel in zone values measured correctly?

- (10) Are the times in the zones correct?
- (11) Are the computations of zone wind speeds correct?
- (12) Have the data for ballistic winds been plotted correctly?
- (13) Were the ballistic wind directions read correctly?
- (14) Were the ballistic wind values read correctly?

NOTE: This checklist applies to the determination of winds for all types of messages.

g. Checklist for completed messages.

- (1) Have all the pertinent data been recorded on the message form? Are the data correct?
- (2) For each message transmitted by radio teletypewriter, does the punch tape agree with the recorded message?
- (3) If a message was transmitted and then found to be incorrect, was a corrected message transmitted?

7. CHART DRIFT CORRECTIONS.

a. Chart drift is evident when the chart rides off the sprockets of the chart roller.

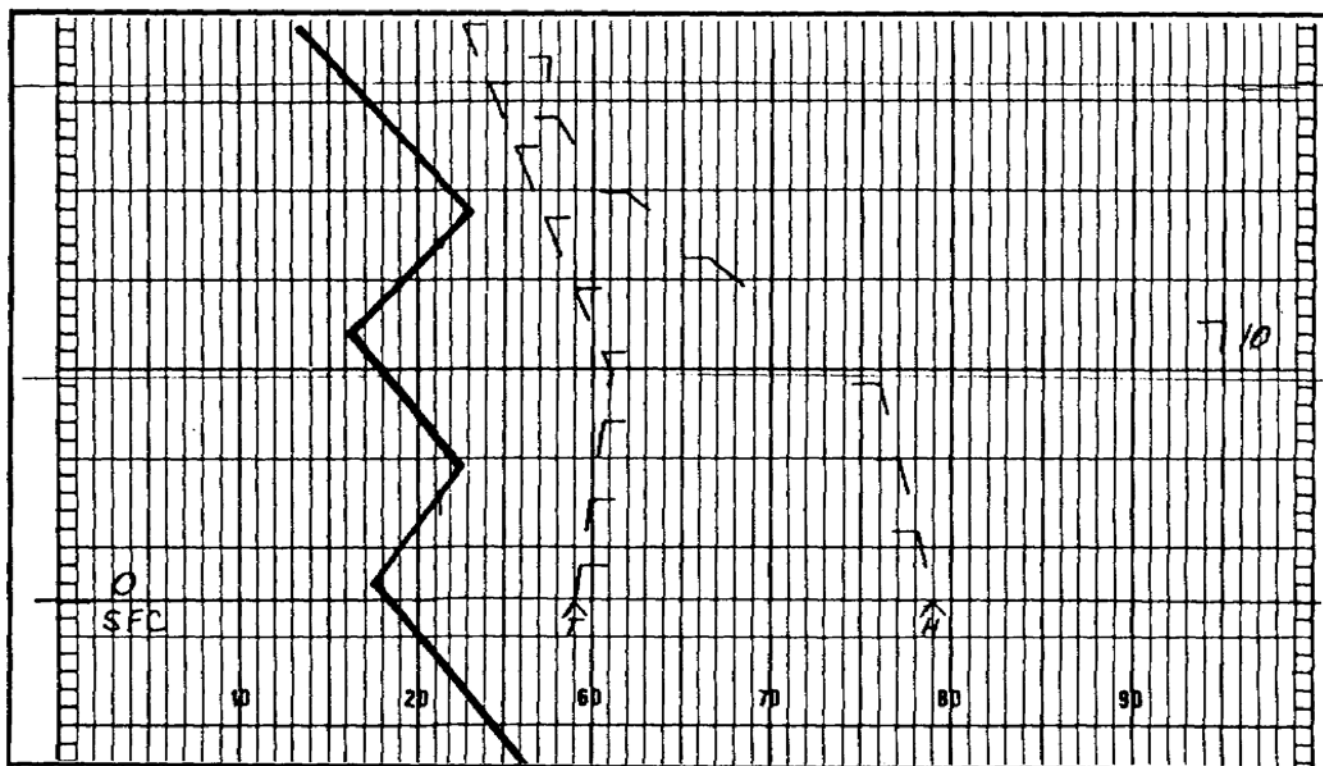
- (1) If it appears that the chart is drifting while a flight is being recorded, the SIGNAL SELECTOR switch is rotated to the S.C. position for about 10 seconds to obtain a zero print.
- (2) This check is made at a point in the record where no significant data will be lost; for example, during a reference trace (after adjustment) or a long temperature trace.
- (3) Successive zero prints are connected with a thin straight line.
- (4) The difference between the position of this chart drift line and the zero R.D. line is the amount of chart drift.

b. If chart drift corrections are needed, they will be applied to the temperature and relative humidity recorder division (RD) values before making the linearity and frequency drift type of corrections.

- (1) The corrections will be the RD difference between the chart drift line and the correct value of the zero setting.
- (2) To establish the proper frequency drift correction to apply, the chart drift correction must be applied to the frequency drift line at 95.0 RD before a frequency drift correction is determined.

PRACTICE EXERCISES:

6. Levels have been drawn at 9.7 and 14.0. What is the humidity recorder division at 9.7 contacts?
- 75.8
 - 75.3
 - 75.0

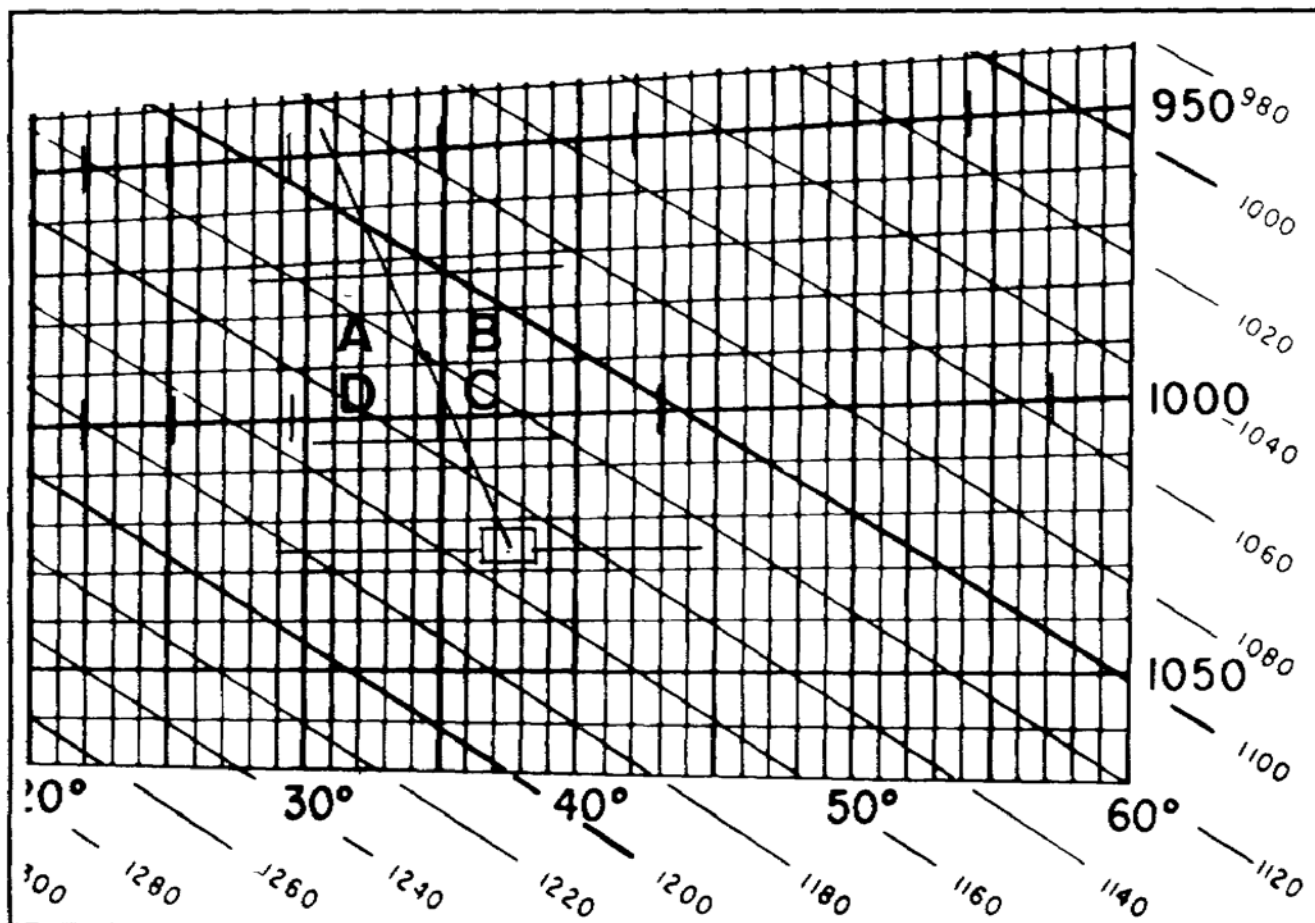


7. What is the actual virtual temperature for line 3 of the radiosonde data sheet?
- 5.2
 - 5.5
 - 5.8

RADIOSONDE DATA FOR USE OF THIS FORM, SEE CHANGE 1, FM 6-15; THE PROPONENT AGENCY IS TRADOC.										
STATION		LOCATION		RELEASE TIME		DATE		HOUR	FLIGHT NO.	
				LST						
				GMT						
LEVEL NUMBER	PRESSURE			TEMPERATURE					RELATIVE HUMIDITY	
	TIME (A)	CONTACT (B)	MILLIBARS (C)	RECORDER DIVISION (D)	°C (E)				RECORDER DIVISION (H)	% (J)
BASELINE CHECK DATA		7.0	984	72.8	30.0				77.6	33
				14130	DEPN	ACTUAL VIRTUAL TEMP (F)	VIRTUAL TEMP CORR 100% (G)	ACTUAL VIRTUAL TEMP CORR (H)	11180	
SURFACE RELEASE DATA 0		7.0		60.4					50.7	
1		10.2		63.0					54.4	
2		14.0		56.7					58.8	
3		18.7		54.1	-5.5		0.5		61.1	55
4		21.0		52.7					57.0	
5		24.5		50.6					81.0	

8. Where is midpoint density recorded on the ML-574 chart?

- a. A
- b. B
- c. C
- d. D



9. What is the zone four temperature percent of standard?

- a. 100.7
- b. 100.6
- c. 100.5

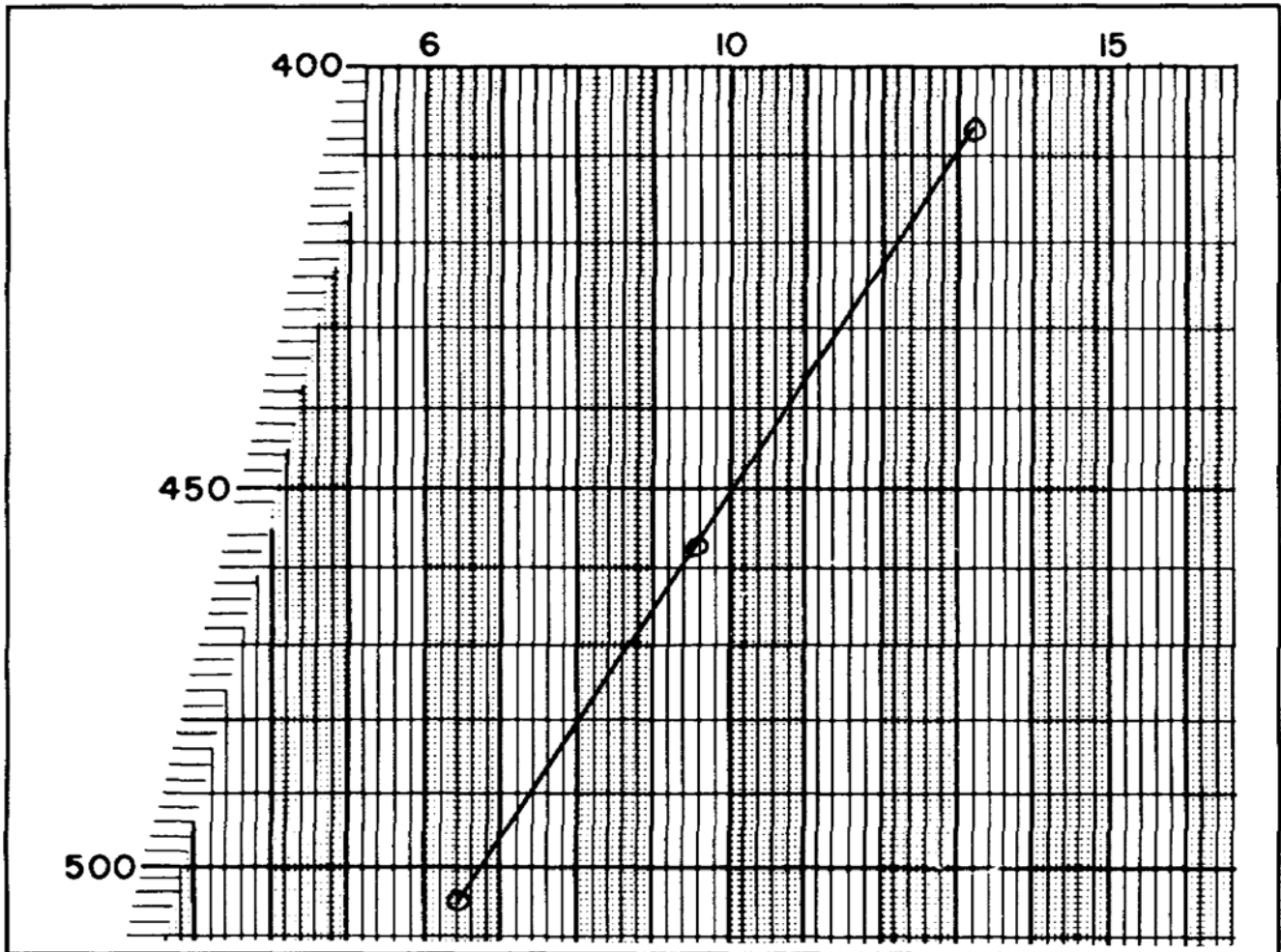
BALLISTIC DENSITY OR TEMPERATURE (FM 6-15)									
STATION			LOCATION						
ZONE NUMBER	(CHECK ONE) ☐ DENSITY Gm/M ³ ☒ TEMPERATURE (C°)	PERCENT OF STANDARD (2)	WEIGHT						
	(1)		1	2	3	4	5	6	7
SUR 0	15.9	100.3							
1	14.5	100.0	100.0	27.0	13.0	8.0	5.0		
2	11.2	99.5		72.7	19.9	11.9	10.0		
3	11.8	100.6			67.4	25.2	20.2		
4	8.7	100.7				55.4	21.2		
5	0.7	99.0					43.6		
BALLISTIC VALUES									
MESSAGE TYPE (CHECK ONE)		COMPUTER							CHECK
S	A								

DA FORM 6-44
1 MAR 62

REPLACES DA FORM 6-44, 1 JUL 55 AND 1 JUL 56, WHICH ARE OBSOLETE.

10. What is the time from the pressure-time chart at 461 millibars?

- a. 9.2
- b. 9.3
- c. 9.4



11. What is the wind speed when the travel in zone is 1,250 meters and the time in zone is 3.2 minutes?
 - a. 11
 - b. 13
 - c. 15
12. Which chart correction is made first?
 - a. linearity
 - b. chart drift
 - c. frequency drift

ANSWERS:

6. b.
7. a.
8. b.
9. c.
10. b.
11. b.
12. b.

8. SUMMARY. The mission of the met section is to produce met data for use by various units. It is imperative that these using units receive the best data possible. The section chief can ensure this by performing quality control of all met information transmitted from his met section.