FM 6-15
MCWP 3-16.5

Tactics, Techniques, and Procedures for

FIELD ARTILLERY METEOROLOGY

HEADQUARTERS
DEPARTMENT OF THE ARMY
UNITED STATES MARINE CORPS

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FOREWARD

This publication may be used by US Army and US Marine Corps forces in conjunction with appropriate technical manuals during training, exercises, warfighting, and stability and support operations.

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Development Command

PREFACE

PURPOSE

The purpose of this publication is to provide United States Army and Marine Corps (USMC) commanders, artillerymen, and met crew members with tactics, techniques, and procedures for the employment of met sections.

SCOPE

The publication describes the equipment and tasks required to develop met data from the selection of the met station location to the dissemination of the met data.

This publication implements the following North Atlantic Treaty organization (NATO) standardization agreements (STANAGs) and quadripartite standardization agreement (QSTAG) 1166, Edition 1, *Artillery Procedures*, (QSTAG 1166 combined all previous artillery related QSTAGs):

- STANAG 4044, Edition 2, *Adoption of a Standard Atmosphere*.
- STANAG 4061, Edition 8, *Adoption of a Standard Ballistic Meteorological Message*.
- STANAG 4082, Edition 1, *Adoption of Standard Artillery Computer Meteorological Message*.
- STANAG 4103, Edition 3, *Format for Request for Meteorological Message for Ballistic and Special Purposes*.
- STANAG 4140, Edition 1, *Adoption of a Standard Target Acquisition Meteorological Message*.
- STANAG 4168, Edition 1, *Characteristics of Hydrogen Generating Equipment*.

APPLICABILITY

Tactical forces of the US Army and Marine Corps may use this publication. It applies to all planning and warfighting personnel.

USER INFORMATION

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Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

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TACTICS, TECHNIQUES AND PROCEDURES FOR FIELD ARTILLERY METEOROLOGY

TABLE OF CONTENTS

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Chapter 1
Commander and Staff Considerations

Combat experience has proven the importance of providing accurate and timely meteorological data to both artillery and other units. Meteorological sections provide data to enhance first round accuracy, effective downwind predictions, intelligence preparation of the battlefield, and forecast capabilities of the staff weather officer. The commander and staff who include meteorology in the planning process benefit the most. The planning process needs to focus on what data is needed, who needs it, and how will they get it.

Section I
Overview

NOTE: The US Army Intelligence Center and Fort Huachuca is the proponent for Army general and tactical weather requirements except those relating to artillery met.

1-1. MISSION

The mission of the met section is to produce and disseminate valid and timely met data in formatted messages. Example messages and checking procedures are at Appendix A. These messages are as follows:

- Computer.
- Ballistic (type 2 and type 3).
- Target acquisition.
- Fallout met (FOMET).
- World Meteorological Organization (WMO) messages.
- Sound ranging messages to allied units.

1-2. US ARMY MET SECTIONS

There are two met sections organic to a heavy division artillery. Only one met section is organic to each light division artillery, field artillery (FA) brigade, and separate maneuver brigade artillery battalion.

1-3. US MARINE CORPS MET SECTIONS

There are four met sections in an artillery regiment. Normally these sections are further assigned the mission of direct support to each of the artillery battalions within the regiment.

1-4. MET SYSTEMS

There are two basic met systems deployed throughout the field artillery: the Meteorological Data System (MDS), AN/TMQ-31, and the Meteorological Measuring Set (MMS), AN/TMQ-38 or the AN/TMQ-41. These systems are highly mobile, automated data processing and met data acquisition systems. All systems operate in any type of climatic condition and over any type of terrain where tactical operations require employment of FA. The systems use two passive modes to track a balloon-borne radiosonde that transmits the upper air data to the ground station. These are the radio navigational aid (NAVAID) and radio direction finding (RDF) modes. All systems have a remote launch capability. The AN/TMQ-31 and 41 can track the radiosonde and process data while on the move. If electronic tracking equipment fails, the MDS equipped section is the only one that has an alternate, but limited, method of measuring upper air winds. This is the visual method of pilot balloon (PIBAL) observation system. Through the use of atmospheric tables, the PIBAL method

determines upper air densities and temperatures. A similar solution is under development for the MMS, AN/TMQ-41, which will provide nine-line extrapolated meteorological information based on surface data.

1-5. CAPABILITIES

Met sections are equipped to produce electronic soundings of the atmosphere to 30,000 meters, day or night, in various types of weather. An important factor in providing met data is the time required for a balloon to reach a required height. Generally, altitude requirements for artillery met messages are low, 10,000 meters or less. Air Force weather (AFW) and nuclear, biological, and chemical (NBC) support are high altitude soundings requiring more time. The met section can provide hourly artillery met data if necessary during high-intensity battle. The artillery meteorologists do not forecast weather; that is the responsibility of the staff weather officer (SWO). However, the met crew member can distinguish major types and changes of weather that will affect the validity of met messages. This knowledge allows him to recommend changes to met flight schedules to provide accurate met data during changing weather conditions.

1-6. COMMAND AND CONTROL

Command and control (C2) of artillery met sections is exercised at the artillery headquarters to which the met section is assigned or attached. However, coordination and planning for met support usually begin with the corps artillery operations officer (G3). The corps artillery G3 has input regarding the location of the met sections to ensure adequate coverage of the corps area. He may recommend tasking the mission for high-altitude soundings (WMO and FOMET messages) to divisions on a rotational basis. An example of decentralized control of met assets is a met section deployed forward to support the covering force battle. In this situation, it is best to attach the supporting met section to the force artillery headquarters of the covering force.

a. **Corps Artillery Assistant G-3**. Although the corps artillery G3 has staff responsibility for the overall operations of artillery met assets in support of corps operations, the assistant G3 operations officer advises the G3 on met matters. He coordinates met requirements between the G3 and subordinate units. Specifically, the corps assistant G3--

- Advises the corps artillery commander, G2, G3, and G4 on artillery met matters.

- Coordinates met matters with the SWO, the chemical officer, the signal officer, the operations-intelligence officer, and allied artillery staff officers.

- Provides the met input to the corps tactical standing operating procedure (TSOP) and operation order (OPORD), ensures their implementation, and rewrites and updates and/or edits them when necessary.

- Makes recommendations regarding the employment of met sections within the corps area.

- Coordinates activities of met sections in the corps with division artillery (divarty) and FA brigade S3s, to include the recommended scheduling of balloon release times for corps-wide met coverage.

- Recommends tasking divisions within the corps as needed to conduct high-altitude soundings required for producing WMO and FOMET messages.

- Advises the corps signal officer on and assists him in assignment of radiosonde transmitting frequencies.

b. **Artillery S3**. The artillery S3 has primary staff responsibility for the control and operations of artillery met assets. The S3 is advised on the technical aspects of met systems by the meteorological (met) station leader. For met employment, the S3--

- Prepares the met plan, which is a tab to the FA support plan. During the preparation of the met plan, considers the following:

  – Commander's intent and concept of the operation.

  – Tactical situation.

  – Terrain features and wind direction.

  – Met assets available.

  – Location of units to be supported.

  – Communications means required.

  – Scheduling requirements.

- Coordinates with the SWO to determine AFW requirements.

- Coordinates with met station leader and unit signal staff officers to prioritize means of communication and dissemination of messages and to assign radiosonde frequencies.

- Coordinates all radiosonde flight schedules of met sections within the area of operations (AO) to provide optimal coverage to supported units. This is very important when providing met support for other than artillery requirements, since flight times are longer for these missions.

- Monitors the operational status of met sections regarding personnel, main-tenance, and logistics.

- Advises the commander on factors affecting met section mission capabilities.

- Coordinates with adjacent units and the assistant G3 at corps to maximize met message coverage. Met messages from adjacent units may be used.

- Coordinates with the met station leader to develop a positioning scheme for all met assets in support of the mission.

- Coordinates with maneuver and supported units to gain approval to move met sections through and to occupy terrain.

- Coordinates with the met section and supported units to execute remote launch procedures to expand areas of validity.

c. **Met Station Leader**. The met station leader is the primary advisor to the artillery S3 in all matters pertaining to met support in the division area. With the S3, he plans the tactical employment of all met assets. He also is responsible for the day-to-day operations of the met section. Specifically, the met station leader--

- Helps the S3 prepare the met plan.

- Advises the S3 on the employment and operation of the met assets within the division area.

- Supervises met section operations.

- Coordinates with the S4 for logistical support.

- Performs site selection and location.

- Directs the operation, emplacement, and displacement of the met section.

- Maintains quality control of met data.

- Organizes and supervises the met section training program.

- Advises the S3 on all factors affecting mission capabilities, such as personnel, maintenance, and logistics.

Section II

Operational Considerations

1-7. SCHEDULING AND POSITIONING

a. **Notice to Airmen**. Routine rawinsonde/ radiosonde observations are, in general, exempt from the provisions of Federal Aviation Regulation 101 relative to filing a notice to airmen (NOTAM) for the following reasons:

- Radiosondes do not weigh more than four pounds or have a weight/size ratio of more than three ounces per square inch on any surface of the package.
- Balloons do not carry a total payload package weighing more than six pounds.
- Balloons do not transport two or more packages that weigh more than 12 pounds.
- Trains do not use a rope or other devices for suspension of the payload that require an impact force of more than 50 pounds to separate the suspended payload from the balloon.

b. **Scheduling**. The S3 is responsible for scheduling flights within the division zone. Users who require met support and who are not in normal met message dissemination schemes forward their request for met support to the artillery S3. The format for the request is at Appendix C. The S3 will coordinate with firing units and other met data users (especially the SWO for AFW requirements and the chemical officer for downwind prediction requirements) to determine if there are any special requirements that must be considered. The S3 includes the flight schedule in the met support plan. In coordination with the met station leader, the S3 develops a flight schedule based on the following:

- Mission requirements (low and high altitude flights).
- Area of validity (terrain).
- Prevailing winds.
- Transition periods.
- Availability of supplies.

(1) **Mission Requirements**. A limiting factor in determining mission assignments is the time required for a sounding balloon to reach a required altitude. When in position, a met section can produce all types of met messages for low-level artillery fire about 30 minutes after releasing the balloon. A high-altitude mission requires about 90 minutes from the release time. When units are coordinating met requirements, they must be careful not to request higher altitudes (more lines) than required. Requesting higher altitudes causes a delay of message delivery times due to the increased time needed to reach the higher altitudes. See Appendix C for met message request format.

(2) **Positioning Met Sections and Area of Met Validity**. The S3 consults with the met station leader to analyze the terrain and its effect on the area of met validity (AMV). The following is a planning guide based on the meteorological datum plane (MDP). See Figure 1-1.

(3) **Prevailing Winds**. The prevailing winds and their effects on the flight path of the balloon are important factors in positioning met sections. The soundings made by the met section only begin at the location where the instrument is released. The remainder of the data is acquired along the balloon path as it rises. The ideal met section location allows for the balloon to travel to the horizontal and vertical location corresponding to the maximum ordinate of the projectile. Based on knowledge of the prevailing winds in the area, the met station leader advises the S3 on the sites that will provide the best met coverage of the battlefield. Information on prevailing winds in general may be obtained from the climatological data provided in the OPORD. This data can also be obtained from the supporting SWO.

(a) If the prevailing wind pattern is such that the contemplated balloon path is beyond the forward line of own troops (FLOT) the section may be employed farther from the FLOT. (See Figure 1-2, (A)).

(b) If the prevailing wind pattern is from a flank, (see Figure 1-2, (B)), the met section is employed so that the sounding balloon will measure the atmosphere in the zones where most of the weapon trajectories will pass.

(4) **Transition Periods**. The validity of a met message decreases over time. There are no specific rules for determining how long a met message is usable, since that determination depends on the atmospheric conditions. The general guidance to help the S3 prepare flight schedules for soundings is discussed below. (See Figure 1-3.)

(a) During and just after sunrise, temperature changes occur as the atmosphere becomes heated. Temperatures are more stable throughout the afternoon. Therefore, soundings are performed more often (every 2 hours) in the morning and less often (every 4 hours) in the afternoon.

TYPE TERRAIN	AREA OF VALIDITY
LEVEL	20-KM RADIUS
MOUNTAINOUS	10-KM RADIUS
COSTAL	15-KM RADIUS

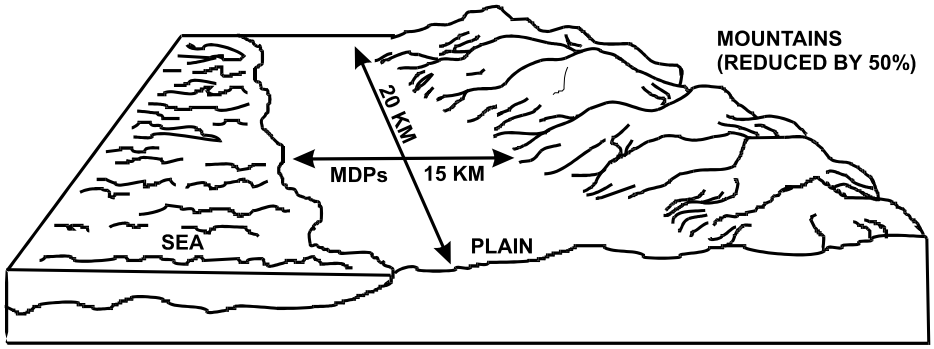


Figure 1-1. Met Message Areas of Validity

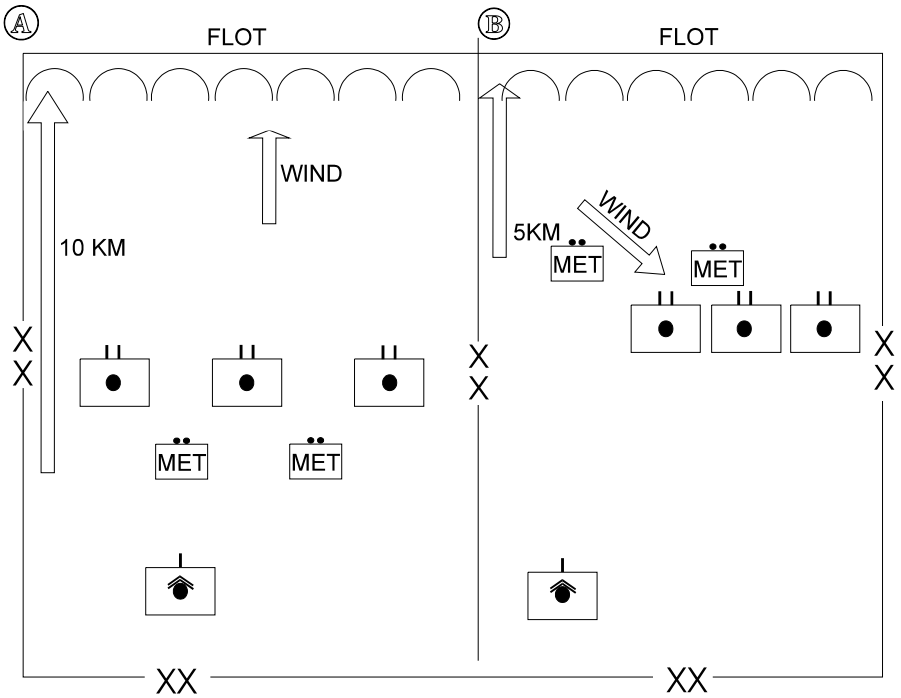


Figure 1-2. Examples of Positioning for Wind

(b) As sunset approaches, the air cools rapidly. During this time, changing temperatures are monitored closely. Flight schedules may need adjusting (to one every 2 hours) as the atmosphere cools. The cooling of the air stabilizes about 2 hours after sunset.

(c) During night and early morning hours, the atmosphere reaches maximum cooling and becomes stabilized. During this time, soundings could be taken at intervals that exceed 2 hours, and 4-hour intervals between flights are common.

(5) **Frontal Passages**. The passage of a weather front is associated with changes in current conditions. Because of this, the met section should conduct a sounding immediately following the passage of a front. As a result met schedules may be adjusted.

(6) **Commander's Intent**. Regardless of the above, the tactical situation and the immediate needs of the field artillery commander are the main considerations that determine positioning and scheduling.

1-8. MET MESSAGE SELECTION

When met messages from several sections are available, the selection criteria below should be used to determine which met section should provide support to a given unit. The following criteria are established and proven by controlled live-fire testing. Variations of this priority may exist. The met station leader can provide guidance in this area and advise when the use of one met message is better than the use of another.

- The best data are current and provided by a met section and balloon flight path within 20 kilometers (km) of the midpoint of the projectile trajectory.

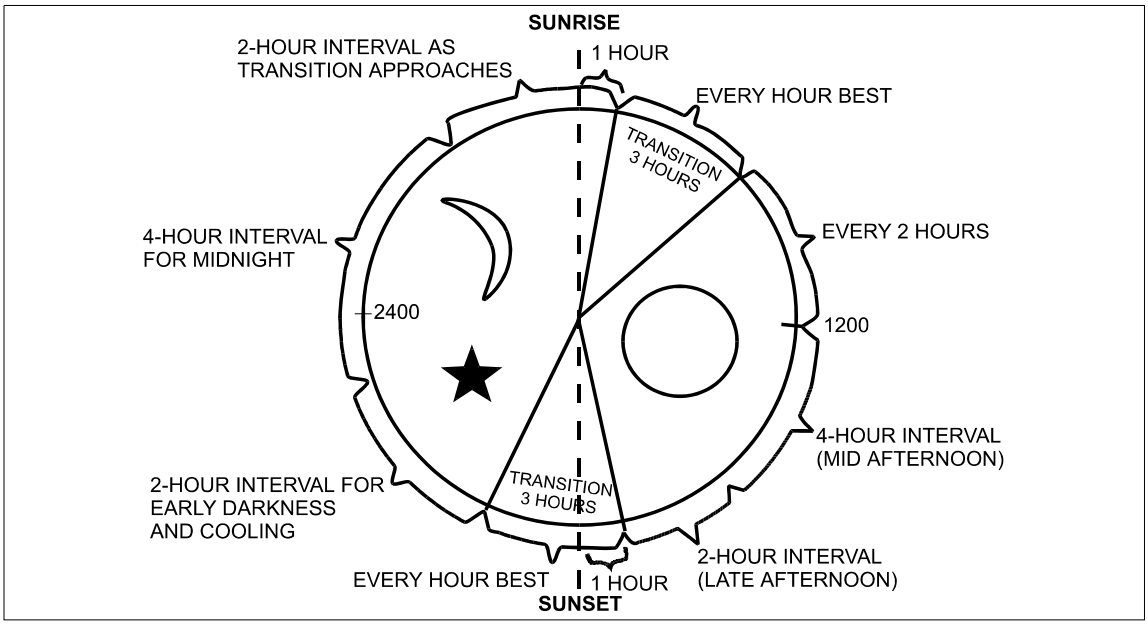


Figure 1-3. Met Day

- The second best data are less than 2 hours old and from the nearest section within 80 km from the trajectory midpoint (upwind is best).

- The third best data are between 2 to 4 hours old and from a section within 20 km of the trajectory midpoint.

- The fourth best data are from a 4-hour old message, if provided by a section and balloon flight path within 20 km of the projectile trajectory midpoint.

1-9. EMPLOYMENT PLANNING

NOTE: Met sections may use hydrogen gas for inflation. This gas is extremely volatile. Leaders at all levels must consider safety and environmental protection requirements during the planning process. See Appendix H for additional information.

When planning the employment of artillery assets in the division area, the commander and staff use the staff planning process outlined in FM 101-5. The planning of met operations in support of the commander's intent and concept of the operation should be included in this process. This planning is done by the S3 and the met station leader.

a. **Mission, Enemy, Terrain, Troops and Time Available**. Selection of modes of operation and general position areas for met sections is influenced by a thorough analysis of the mission, enemy, terrain, troops, and time available (METT-T).

(1) **Mission**. The type of mission assigned to a met section greatly influences its positioning. The main consideration in positioning a met section when it is providing met data in support of artillery operations is to locate the section where it provides optimum coverage for the most firing units. Other (high-altitude) met support require-ments, such as AFW support and FOMET message production to support smoke or NBC operations, also influence the positioning of met assets.

(2) **Enemy**. The enemy situation, capabilities, and probable courses of action developed by the S2 during intelligence preparation of the battlefield (IPB) greatly determine the employment of met assets. Security of the sections must be weighed against mission requirements.

(3) **Terrain**. Terrain acts upon the area of validity of met messages. Generally, the AMV decreases as the distance from the user increases. Mountainous terrain and large bodies of water also affect validity areas.

(4) **Troops**. The size of the area to be covered and the disposition of artillery units greatly govern the way the met section is employed. The section must be positioned where it can provide support for the largest number of firing units. Met sections also should be located where logistical support can be provided. Finally, met sections must be within effective and practical communications range of the units they support.

(5) **Time Available**. The S3 and the met station leader must consider how much time is required for reconnaissance, movement, and occupation of initial and subsequent section positions. Upon arrival at a location, the met section requires about 30 minutes to emplace. Displacement time is approximately 60 minutes. Travel time is figured at the standard rate for the local conditions for wheeled vehicles.

b. **Employment in Support of Intelligence Preparation of the Battlefield.** The weather analysis has a great impact on both friendly and enemy capabilities. Analyzing the weather data in detail to determine their effect on friendly and enemy capabilities to move, shoot, and communicate is essential to the IPB process. Because weather also has a tremendous effect on terrain, met section input to terrain and weather analysis is a crucial part of the METT-T methodology.

(1) The SWO is responsible for providing weather information for the AO and the area of interest (AI) as part of the weather analysis process. The artillery met section provides critical surface and upper atmospheric weather data in support of weather analysis to the SWO.

(2) The S-3 considers high-altitude requirements, WMO, and FOMET, as well as artillery requirements when positioning and scheduling a met section. Direct coordination among the S2, SWO, and S3 is required to determine requirements in support of the weather analysis process.

1-10. TACTICAL MOVEMENT

A met section may deploy anywhere on the battlefield to achieve its mission of providing met support. Movement may be toward or away from the FLOT or laterally, depending on weather conditions (mainly prevailing wind direction) and the tactical situation. The requirement to provide continuous coverage is an important consideration in determining movement schedules. A number of widely separated section positions must be planned. Additionally, an analysis of areas of met validity is necessary. Primary, alternate, and possibly even third-choice position areas are selected. The S3 coordinates with the maneuver element to receive approval for occupation of positions and to obtain route clearances. Met sections then must conduct reconnaissance and select the most suitable sites within the areas.

a. **Met Support in the Offense**. Each met section must be prepared to increase the frequency of message production. Planning in support of the operation must ensure adequate supplies are available to meet increased demand. Prior planning allows the met section to increase frequency of flights and transmissions of met data, thereby improving the firing accuracy of the force.

b. **Movement Technique**. The basic movement technique is leapfrogging. When the battle is fluid and the rate of movement is rapid, met sections may employ the leapfrogging technique to keep pace. In this technique, one met section, having established a position, remains in operation while a second displaces to a new location. When the second section becomes operational, the first section is displaced by moving past the newly occupied position of the second section. This procedure is repeated as often as necessary. (See Figure 1-4.)

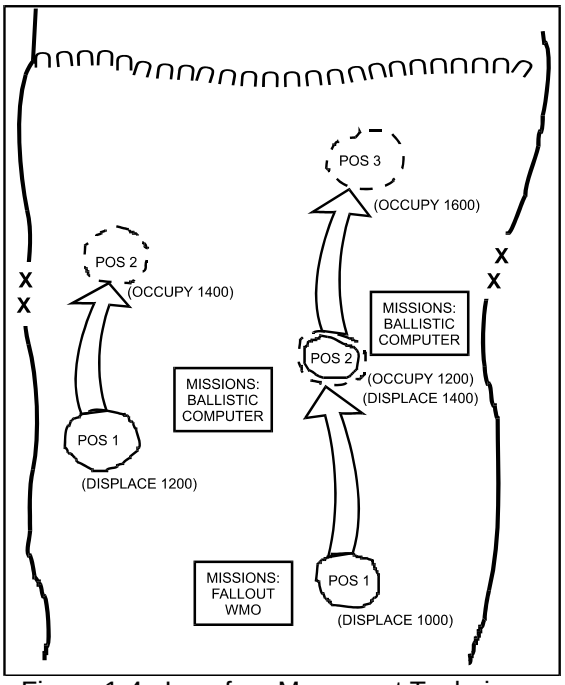


Figure 1-4. Leapfrog Movement Technique

c. **Met Support in the Defense**. Accurate, concentrated artillery fire is a key element in any defense. Met messages improve the effectiveness of the artillery response by increasing the accuracy. Control of the met section in the defense is normally centralized once the main battle commences. Movements are limited to ensure continuous support.

1-11. COMMUNICATIONS

a. **Communications Plans**. Met data are perishable. The timely dissemination of messages is essential. Digital communi-cations is the primary means of met message distribution. Met messages may be disseminated in a centralized or decentralized manner, depending on the tactical situation. Centralized dissemination normally is used when the tactical situation is stable. Decentralized dissemination may be used when the controlling headquarters is continually relocating or its capability to relay data was terminated. (See Figure 1-5.) The communications plans must support the deployment of met assets within the AO. The S3 establishes communications priorities and means of dissemination and incorporates them into the met plan. Unit plans and procedures documents should address the following:

- Communications means.
- Assignment of radiosonde frequen-cies.
- Procedures for coordinating met support from adjacent units.
- Procedures for passing AFW and FOMET messages to divarty fire support element (FSE).

b. **Methods of Communication**. The met section normally transmits all messages to its controlling headquarters' fire direction center (FDC). The FDC then passes the met messages electronically to the using elements. The FDC must pass the AFW and FOMET messages to the divarty FSE for dissemination to the SWO and chemical officer at division. This data is used for forecasting, downwind predictions, and close air support.

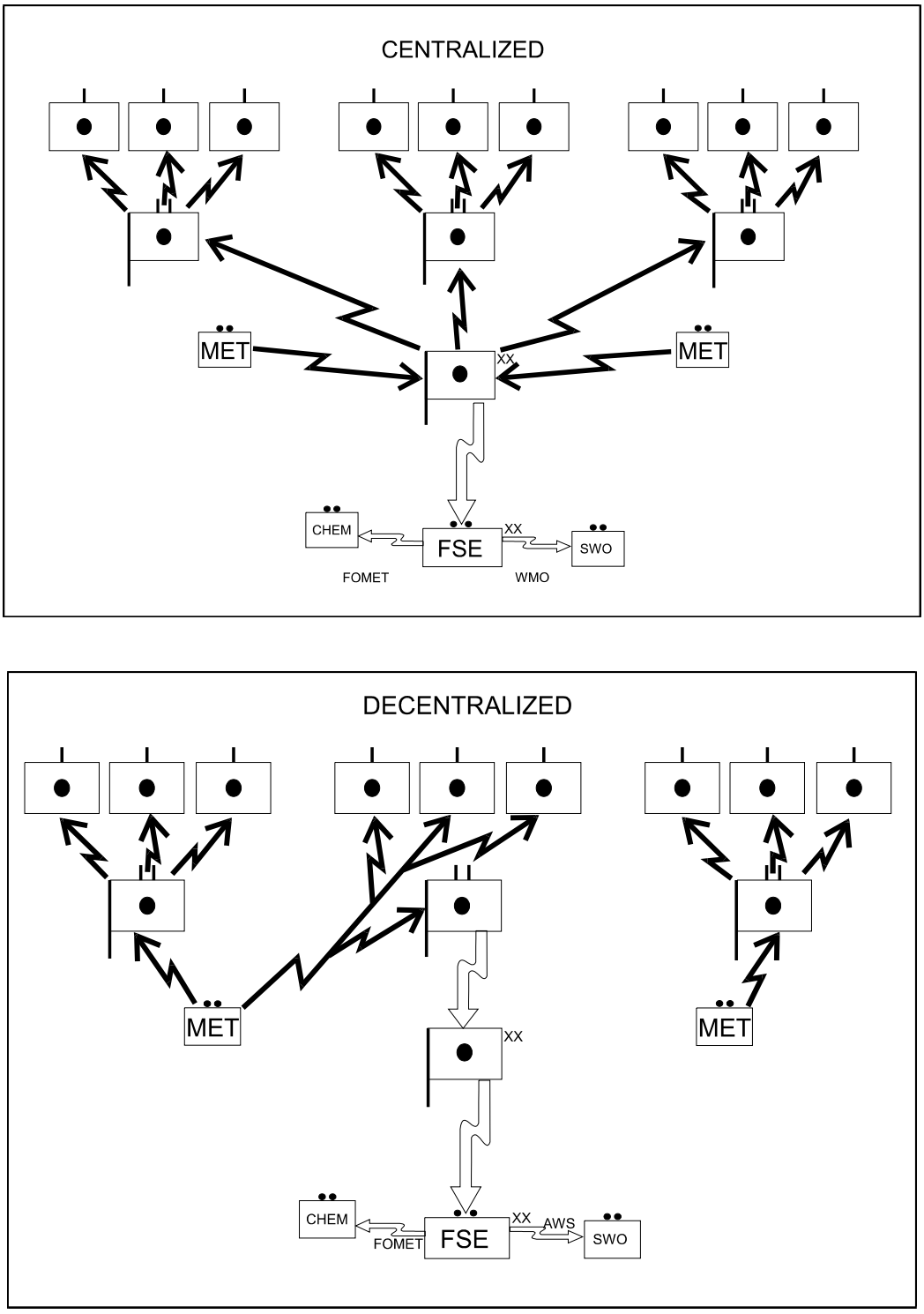


Figure 1-5. Centralized/Decentralized Communications

(1) **Radio Communications**. Each met section is authorized the single-channel ground and airborne radio system (SINCGARS). The section operates in two tactical radio nets as directed by the controlling headquarters. Normally, these are the FA command net for C2 and a FA operations/fire net for met message dissemination. When digital radio communication is not possible, the met section may disseminate messages by frequency modulation (FM) voice.

(2) **Wire**. Whenever practical, wire lines are installed for voice and digital communications with the supported units. Radios serve as a backup means of dissemination.

(3) **Messengers**. Messengers may be used when communications systems are not functioning or if the supported unit is nearby. However, extensive travel time for delivery may exhaust the validity time.

1-12. MET PLAN DEVELOPMENT

The met plan contains the information needed to understand how met assets will be used during a specific operation. The met plan conforms to the standard five-paragraph OPORD format. The heading of the plan includes the security classification, the title line, references, and the time zone used throughout. The classification is shown at the top and bottom of each page of the document. Major paragraphs of the plan are the same as the five-paragraph OPORD format. See Appendix D for an example of a met plan.

1-13. STABILITY AND SUPPORT OPERATIONS

Field artillery meteorological sections can provide upper air data, wind speed and direction, temperature, and pressure in support of these operations. Military and civilian authorities use this information to maintain current weather maps and to assist them in predicting future conditions. The met sections are also equipped with SINCGARS, which could support the operation as the commander deemed necessary.

1-14. SAFETY IN STABILITY AND SUPPORT OPERATIONS

During these operations helium should be used for inflating balloons. If the section must use hydrogen gas, extreme caution must be taken especially in built-up areas.

Chapter 2
Additional Sources of Meteorological Information

There are additional sources of meteorological information when met data is not available from organic assets. This chapter discusses these sources.

2-1. ALLIED NATIONS

Because there will be occasions when the artillery of one nation may wish to use the meteorological data produced by the meteorological services of another, standard forms of met message structure and standards have been agreed upon. Through North Atlantic Treaty Organization (NATO) standardization agreements (STANAG) and Quadripartite standardization agreements (QSTAG), the US, along with several of its allies, has adopted a standard database from which all meteorological information is derived. This means that atmospheric data can be freely exchanged among member countries with the assurance that the same atmospheric standards were used. Member countries produce ballistic data that is applicable to US Army weapons systems. When exchanging data between member countries, commanders and operations officers must ensure that the validity criteria explained in Chapter 1 are applied. Met station leaders can advise commanders and S3s on these matters. The following is a list of countries that have adopted these standards:

Australia
Belgium
Canada
Denmark
France
Germany
Greece
Italy
Luxembourg
Netherlands
Norway
Portugal
Turkey
United Kingdom
United States

2-2. US AIR FORCE

The US Air Force (USAF) currently has 13 fixed and 15 deployable weather teams deployed throughout the world capable of performing upper air soundings. The information they gather cannot be used for ballistic solutions to the gunnery problem; however, this information can be used by chemical sections for downwind predictions when fallout messages from organic met sections are not available. This additional source of met does not relieve US Army met sections of the responsibility; however, this information can be provided when the US Army cannot produce the data. When available, these teams will normally be employed at corps or higher; however, they could be positioned in areas forward of the division main. Other USAF assets include Special Observation Weather Teams (SOWTs) attached to Special Forces Groups. When approved by the group commander, SOWT members may assist operational detachments in gathering critical weather observations in denied areas to support deep strike operations. This SOWT-derived information is obtained through coordination with the Special Operations Command and Control Element normally attached to corps and higher levels. The weather data gathered through SOWTs in cross-FLOT/fire support coordination line (FSCL) areas are similar in scope to that derived by forward area limited observation program operations conducted in corps/division operational areas. Although this information is unsuitable for met ballistic gunnery solutions, it may prove invaluable for deep attack (missile/rocket) targeting solutions for chemical downwind predictive measurements. Fire support coordinators (FSCOORDs)/FSEs should consider SOWT capabilities when conducting mission analysis for deep strike operations.

2-3. US NAVY

The US Navy has Mobile Environmental Teams capable of sounding the atmosphere and producing ballistic data. The message produced is in STANAG format. These teams are deployed on a mission basis. The teams are composed of one to five members. They typically support their own units, but also support joint operations and could be requested to support US Army artillery operations. Requests for support must be coordinated well in advance of the time of need. Procedures for requesting support are outlined in Navy publication NAVOCEANCOMINST 3140.1J.

Chapter 3
Weather and Its Effects

Weather greatly impacts military operations. Weather data are part of the intelligence information required to plan and conduct combat operations. This chapter discusses terms and the impact weather has on the field artillery operations.

Section I
Elementary Met

3-1. DEFINITION

Meteorology is the science dealing with the earth's atmosphere and its phenomena, including weather and climate. Besides the physics, chemistry, and dynamics of the atmosphere, met includes many of the direct effects of the atmosphere on the earth's surface, the oceans, and life in general. Met effects such as wind, temperature, air density, and other phenomena influence military operations.

3-2. ATMOSPHERE

The atmosphere (Figure 3-1) is the envelope of air that surrounds the earth in several distinct layers. It is the lower portion of the atmosphere that concerns artillery meteorologists.

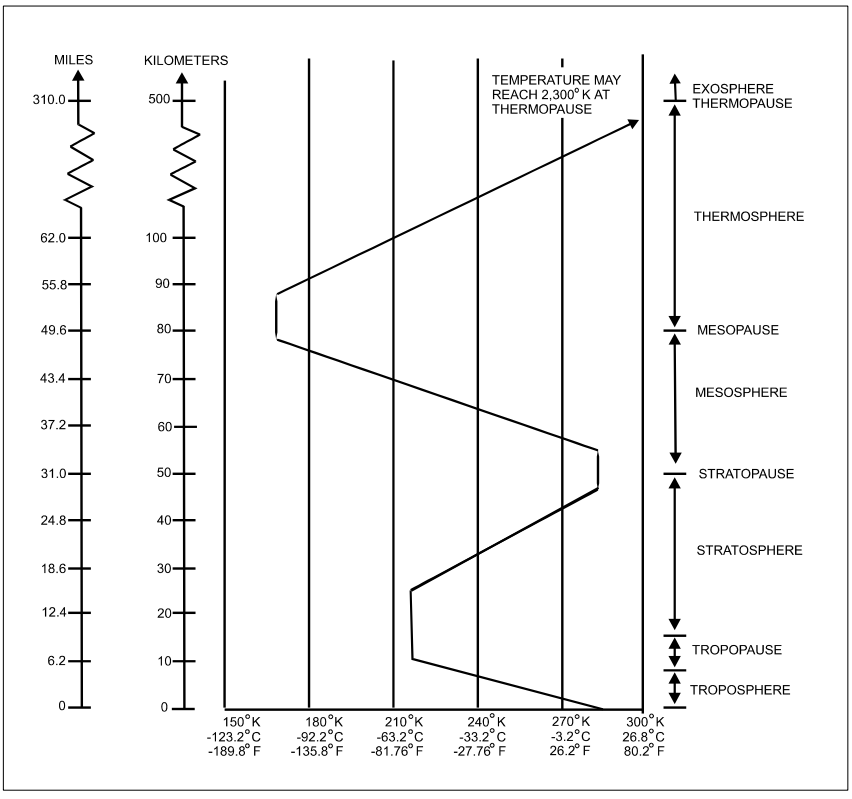


Figure 3-1. Earth's Atmosphere

a. **Troposphere**. About three-quarters of the air in the atmosphere is compressed into the lowest layer, which is called the troposphere. In this layer, the change of temperature in relation to height is relatively large. It is the region where clouds form and air masses continuously mix. Within the troposphere, air consists of 78 percent nitrogen, 21 percent oxygen, and one percent argon, carbon dioxide, and minute amounts of other gases. Air also contains variable amounts of water vapor and a mixture of minute impurities, such as particles of dust and salt. The thickness of the troposphere varies with the season of the year. However, it is generally 8 km thick at the poles and 18 km thick at the equator.

b. **Tropopause**. The top of the troposphere is known as the tropopause. It is a transition zone between the troposphere and the stratosphere. It acts as a lid that tends to hold in the lower atmosphere. This lid contains occasional breaks and overlaps that provide paths for high-velocity winds called jet streams. The jet streams cause constant turbulence and mixing of the lower atmosphere. It is this mixing of air masses that causes our weather. The weather below the tropopause has the greatest effect on artillery operations.

c. **Stratosphere**. The layer immediately above the tropopause is the stratosphere. It has a stable temperature in the lower half of the layer and an almost complete lack of clouds. In the upper half of the stratosphere, at about 25 km, the temperature begins to increase with height up to about 50 km at the stratopause. In the stratopause, the temperature is about the same as that at the earth's surface. This warm region is caused by the presence of ozone, which absorbs part of the ultraviolet radiation from the sun. Without the ozone layer, life on earth would be difficult, if not impossible. Further layers are not discussed because artillery data are gathered only to an altitude of 30,000 meters.

3-3. HEAT

a. **Convection**. Convection is the transfer of heat by the physical movement of heated substances, such as liquid or gas. In met, convection denotes vertical air motion.

b. **Conduction**. Conduction is the transfer of heat between two parts of a stationary system caused by a temperature difference between the parts. Conduction warms the layer of air in contact with the earth's surface during daylight, which causes it to expand and become less dense. The less dense air rises and is replaced by cooler air, which is warmed in turn, thus creating a convective cell.

c. **Turbulence**. On a small scale, this vertical motion is called turbulence and is quite irregular because of unequal heating and cooling over various types of terrain. On a large scale, the vertical motion in conjunction with the horizontal motion carries excess heat from equatorial regions to the cooler areas at higher latitudes. This mass transfer of heat by means of large-scale movement of the atmosphere is essential in the overall heat balance of the world.

3-4. TEMPERATURE SCALES

There are three different scales used to express temperature. The most familiar is the Fahrenheit (F) scale. On the Fahrenheit scale, the freezing point of water is 32°. Another scale is the Celsius (C) scale on which the freezing point of water is O°. The third scale is the Kelvin (K) scale on which the freezing point of water is 273.2°. The Kelvin scale has no negative values and is often used for temperature computations. A direct relationship exits between these scales (Figure 3-2).

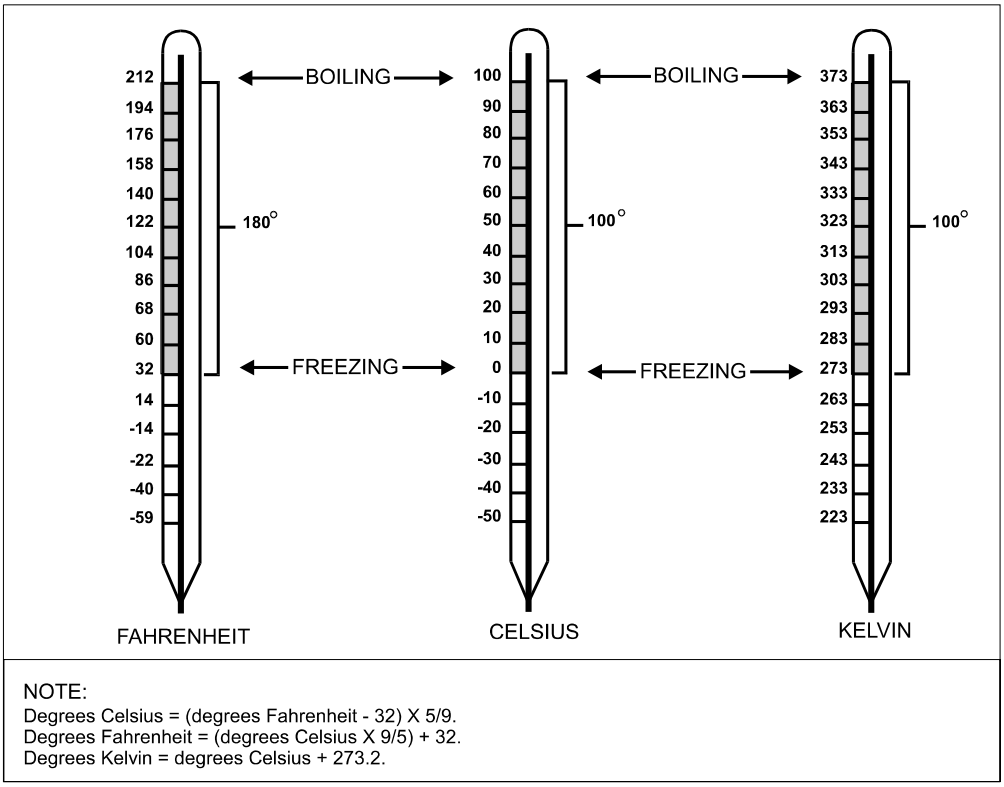


Figure 3-2. Temperature Scales

3-5. MOISTURE

a. **Water Vapor**. The oceans provide the major source of moisture for the air. Every day the energy from the sun transforms millions of tons of water into water vapor. Air currents then distribute the water vapor within the atmosphere. Though water vapor represents only a small percentage of the atmospheric gases, it is by far the most important in relation to weather processes. There is an upper limit to the amount of water vapor that can be contained in any given volume of air at a specific temperature. Warm air can hold more water than cool air.

b. **Relative Humidity**. The moisture content of air can be expressed in several different terms. However, the most common term is relative humidity. Relative humidity is the ratio (percentage) of the actual amount of water vapor present in the air to the maximum amount of water vapor the air could hold at the existing pressure and temperature. As the air cools and its ability to hold water vapor decreases, the percentage of relative humidity increases until saturation (100 percent) occurs. At this saturation point, water vapor begins to condense into water droplets around particles of salt or dust in the atmosphere. As droplets grow bigger and heavier, they eventually fall toward the earth as rain or snow, depending on the temperature of the atmospheric levels through which they pass.

3-6. ATMOSPHERIC PRESSURE

a. **Definition**. Since the atmosphere is a mixture of gases, it is quite natural to think of air as being very light in weight. However, the total weight of the entire atmosphere is tremendous. If the entire weight of the atmosphere were replaced by an equal weight of water, the water would cover the earth's entire surface to a depth of 10 meters. The weight of the air pressing down upon itself

produces atmospheric pressure. Pressure is continuously changing, mainly because of changes in air density brought about by variations in temperature and moisture content. At higher altitudes in the air column, the air pressure is less because there is less air above the higher altitude. More specifically, atmospheric pressure is the weight of a column of air that extends upward to the top of the atmosphere. (See Figure 3-3.)

b. **Pressure Measurement**. Air pressure is measured with barometers and reported in millibars (mb). One type of barometer is mercurial, which is very accurate but not portable. A mercurial barometer measures air pressure in inches of mercury, which are then converted to millibars. Another type of barometer is the aneroid, which measures air pressure in millibars and is portable. A third type of barometer is a digital device that measures and displays pressure in millibars. Artillery met sections use the aneroid and digital barometers.

3-7. CLOUDS

Most weather phenomena are associated either directly or indirectly with clouds. Therefore, observer personnel must understand the significance of clouds. This enables them to make pertinent and timely decisions on the effect of weather on operations.

a. **Cloud Composition**. Clouds are composed of millions of water droplets and/or ice crystals suspended in the atmosphere.

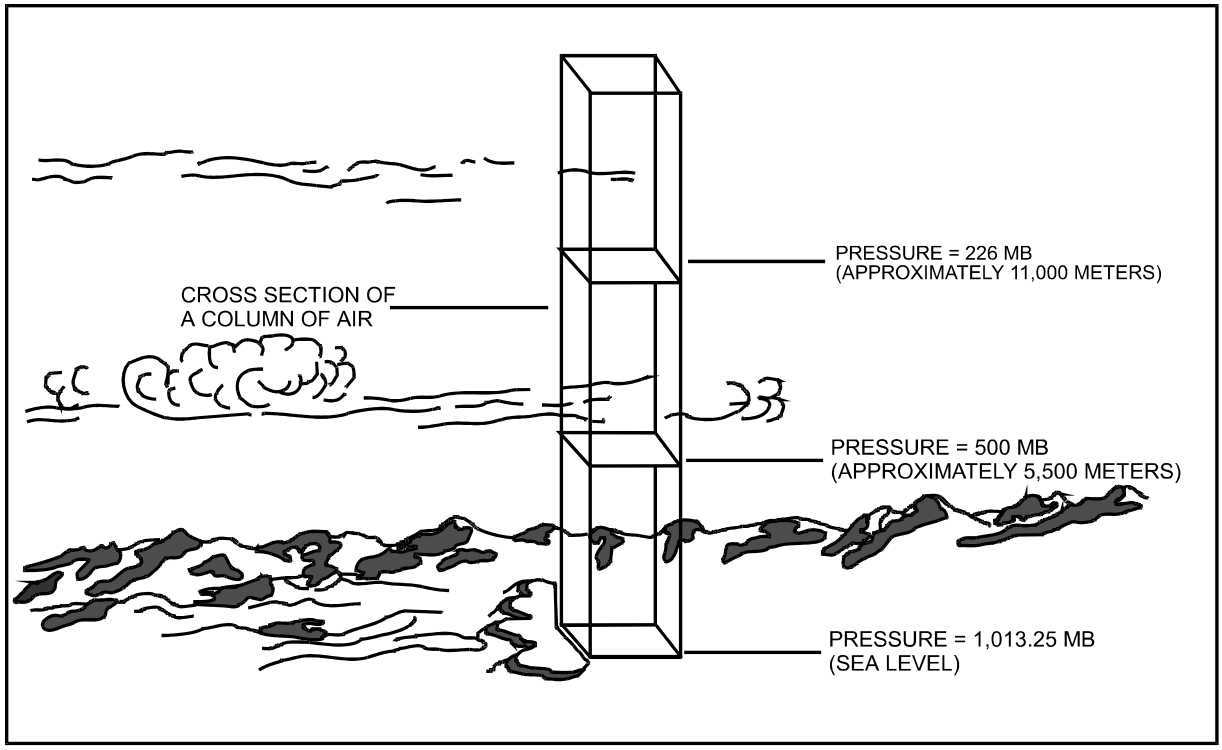


Figure 3-3. Atmospheric Pressure

(1) **Condensation**. Condensation is the process whereby water vapor is changed into small droplets of water. For condensation to occur, there must be something present in the

atmosphere upon which the water vapor can condense. Virtually billions of minute particles, which result from ordinary dust, combustion products, and sea salt crystals, exist in the atmosphere. These particles are condensation nuclei. Condensation of water vapor upon these particles form clouds and fog. Condensation may result from a decrease in temperature, a decrease of pressure, or an increase of water vapor in the air. In the atmosphere, condensation normally occurs when warm, moist air rises and cools by expansion. Frontal activity, terrain features, and unequal heating of land and sea surfaces cause the air to be lifted.

(2) **Precipitation**. Precipitation is visible moisture, either liquid or solid, which falls from a cloud to the surface of the earth. It occurs when the cloud particles become so large that the pull of gravity overcomes the buoyant force of the surrounding air in the cloud. The size of cloud droplets may be increased by collisions with other droplets or by the freezing of supercooled water droplets on ice crystals.

(3) **Virga**. Clouds do not always produce precipitation since the initial water droplets are extremely small and simply float in the atmosphere. Precipitation may fall from clouds without reaching the earth's surface because on many occasions it evaporates before reaching the surface. This phenomenon is called virga.

b. **Cloud Categories**. Clouds are classified by their appearance and the physical processes that produce them. All clouds, by their shape, fall into two general categories, cumuliform (cumulus) and stratiform (stratus). (See Figure 3-4.)

(1) **Cumulus**. Cumulus means heaped or accumulated. Cumulus clouds look that way because they are always formed by rising air currents. Cumulus clouds may produce local showers or severe thunderstorms and extremely strong vertical air currents.

(2) **Stratus**. Stratus, or sheet like, clouds are formed when a layer of air is cooled below its saturation point without pronounced vertical motion. The vertical thickness of stratiform-type clouds may range from several meters up to a few kilometers. Precipitation, if any, from stratiform clouds is generally continuous with only gradual changes in intensity and covers a relatively large area.

c. **Cloud Classification**. Clouds may be further classified as high, middle, low, and towering. (See Figure 3-4.)

(1) **Low**. When the bases of clouds are lower than 2,000 meters above the surface of the earth, the clouds generally are designated as cumulus or stratus, unless they are producing precipitation. In that case, they are referred to as cumulonimbus or nimbostratus. Nimbus means rain cloud. Another common low cloud, with some of the characteristics of both cumulus and stratus clouds, is called stratocumulus.

(2) **Middle**. Between 2,000 and 6,000 meters, clouds generally are identified with the prefix *alto* preceding the cloud name. Altocumulus and altostratus clouds are in this category.

(3) **High**. Above 6,000 meters, clouds are composed of ice crystals and generally have a delicate appearance. These clouds are designated as cirrocumulus and cirrostratus. At still greater altitudes, a fibrous type of cloud, which appears as curly wisps and is composed of ice crystals, is designated as cirrus.

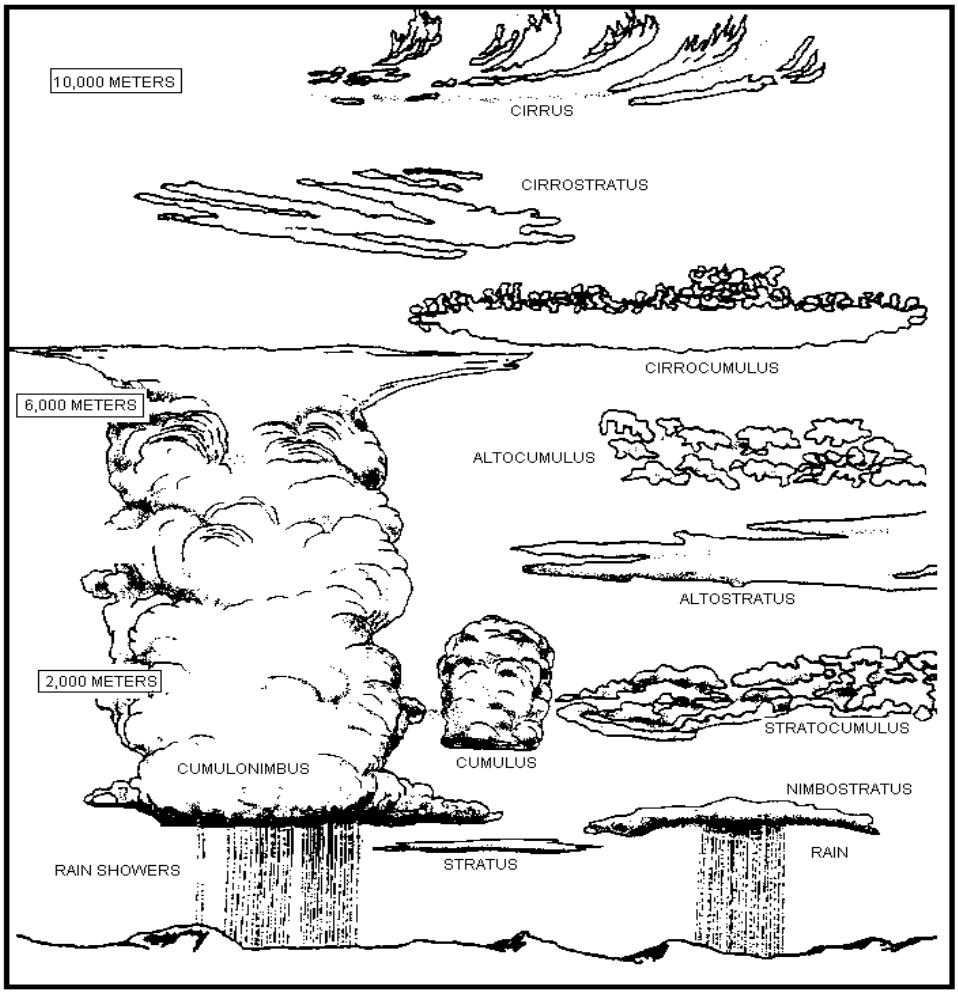


Figure 3-4. Cloud Types

(4) **Towering**. Bases of towering clouds may be as low as the typical low clouds, but their tops may extend to, or even above, the tropopause.

3-8. AIR CIRCULATION

Simple atmospheric circulation is the movement of air over the surface of the earth. Solar radiation is the energy source that heats the atmosphere and sets it into motion. The equator receives the greatest amount of solar heating, while the poles receive the least. This unequal heating creates temperature differences between various locations on the earth. The temperature differences produce pressure changes that cause air motion in our atmosphere.

a. **General Circulation**. General air circulation can be explained by the three-cell theory. Hot, moist air near the equator rises to high altitudes and flows toward the poles. As the air rises and travels away from the equator, it cools and dries, becoming denser. Some of the cold, dry air sinks back to the surface at about 30° latitude. Some of the descending air returns to the equator, replacing the rising, less dense air. Thus, the first cell of circulation is complete. The remainder of the descending air at 30° latitude travels toward the poles along the earth's surface. At about 60°

latitude, this cool air meets the very cold air flowing along the surface away from the poles. The cool air is forced upward until it rejoins the remaining upper air moving from the equator to the poles. Thus, the second and third cells of circulation are formed. (See Figure 3-5.) Within this general pattern of circulation, several semi-permanent pressure regions exist. Low-pressure regions exist at the equator and at 60° latitude. High-pressure regions exist at 30° latitude and in the polar regions.

b. **Earth's Effect on General Circulation**. Irregular formations of land and water, the rotation of the earth, and the tilted axis of the earth affect air circulation. Because water heats and cools much slower than does land, local patterns are set up and superimposed on the general flow. High pressures form over land during winter and over the oceans during summer. This results in large-scale seasonal circulation, such as the monsoon. On a smaller scale, this unequal heating causes a daily circulation pattern along the shoreline. During fair weather, the land is warmed by the sun during the day and cooled by terrestrial radiation at night. This creates a sea breeze by day and a land breeze by night. The rotation and tilted axis of the earth affect circulation patterns.

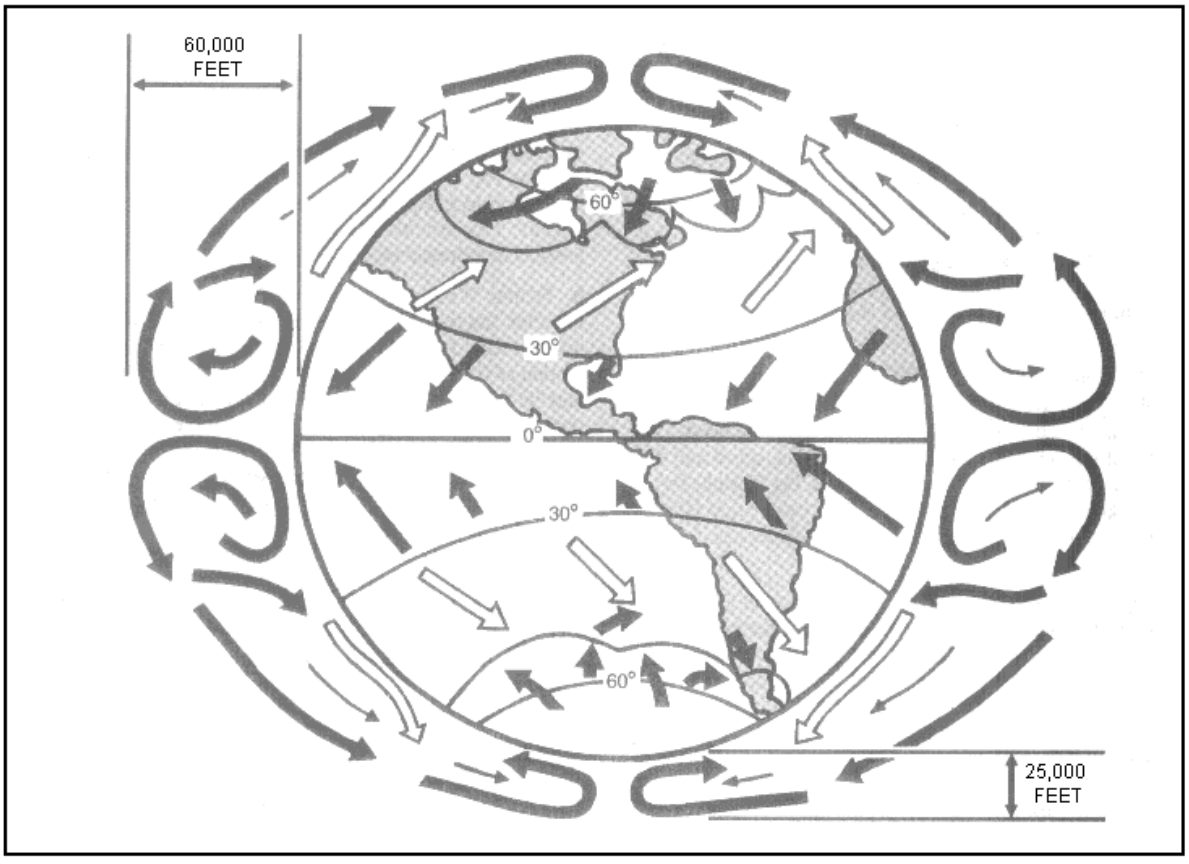


Figure 3-5. General Circulation Pattern

c. **Secondary Circulation**. When air circulates, several forces act to create disturbances and irregularities in the lower levels of the troposphere. The result is secondary circulation, which consists of moving pressure systems that are smaller than the general circulation patterns. These forces are as follows:

- Pressure gradient force.
- Coriolis force.
- Centrifugal force.
- Frictional force.

(1) **Pressure Gradient Force**. The pressure gradient force tends to move air from high to low pressure, normally both vertically and horizontally. Since pressure decreases with altitude, an upward force exists. Vertical air motion may occur over large areas where the mean vertical velocities generally are very slow. Vertical air motion that is restricted to a small column (an updraft) may have velocities greater than 20 knots. Pressure also varies in the horizontal between surface pressure systems. This produces horizontal pressure gradients, which tend to displace the air in the direction of the lower pressure. Although vertical air motion is important in cloud formation and weather, the large-scale wind systems throughout the world consist mainly of horizontal air motion.

(2) **Coriolis Force**. If the earth did not rotate, the air would always move directly toward lower pressure. However, the rotation of the earth causes a deflective force, Coriolis force, which tends to counteract both the vertical and horizontal pressure gradient forces. Coriolis force causes moving air to deflect to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

(3) **Centrifugal Force**. Lines of constant pressure (isobars) usually are curved around pressure systems. This curvature results in a centrifugal force upon the wind. The effect of the centrifugal force depends on the speed and the existing path of the air. In high latitudes, the Coriolis force has a greater effect than does the centrifugal force. However, near the equator, centrifugal force has a greater effect.

(4) **Friction**. Friction tends to slow air movement. Frictional effects on the air are greatest near the ground, but they also are carried aloft by turbulence. Surface friction has a slowing effect on the wind up to about 2,000 feet. Above 2,000 feet, altitude friction effects are negligible.

3-9. AIR MASSES

The physical properties of air masses are largely determined by the type of surface over which they form. A source region for an air mass is an extensive portion of the earth's surface on which temperature and moisture properties are fairly uniform. The time required for a mass of air to acquire the properties of an underlying surface varies greatly with the surface and, in some cases, may take a period of weeks.

a. **Continental and Maritime Masses**. The type of surface determines the basic moisture properties of an air mass. The latitude establishes the basic temperature characteristics of an air mass. The two types of surfaces are continental (land) and maritime (oceanic). The location at which the air mass is formed is either polar or tropical. Therefore, air masses originating in polar regions over land are called continental polar, and air masses formed in tropical regions over the ocean are called maritime tropical.

b. **Movement of Air Masses**. When an air mass leaves its source region, the state of equilibrium that existed with the underlying surface becomes disturbed and the air mass undergoes a modification. The degree of modification depends on the contrast with the underlying surface and the speed at which the air mass is traveling. The modification process is important. It affects the stability of the air mass, which, in turn, influences the type of weather that may be expected. For example, when a continental polar air mass moves over a warmer surface, it absorbs heat from the surface and develops instability in its lower levels because cold air is lying on top of a warm surface. This unstable condition leads to convective activity and the formation of cumulus clouds. The cumulus clouds may provide showers or possibly thunderstorms.

c. **Fronts**. When two or more different air masses come together, the boundary on the surface between the air masses is called a front. Fronts are classified by the relative motion of the warm and cold air masses. The frontal system may be from 10 to 500 km wide, the width varying with the type of front. The height of the front may vary considerably because the frontal surface is not vertical. This is due to the differing densities of the two air masses. The colder air, which is denser (and thus heavier), always wedges under the warmer air mass, causing the warmer air to be lifted. All true fronts actually separate distinct air masses of different densities. A frontal position is characterized by a distinct change in wind direction. The weather associated with fronts is called frontal weather and is more complex and variable than air mass weather. The type and intensity of frontal weather largely depends on such factors as the slope of the frontal surface, the amount of moisture, the stability of the air masses, and the speed of frontal movement. Because of the variability of these factors, frontal weather may range from a minor wind shift with no clouds to thunderstorms, hail, and severe turbulence. The passage of a front may cause rather abrupt changes in the weather.

(1) **Cold Front**. When cold air displaces warm air at the earth's surface, it is called a cold front (Figure 3-6). A slow-moving cold front has a rather gentle slope. However, as the front accelerates, the slope becomes steeper (more vertical) near the surface because of the friction of the terrain. Cold fronts normally move faster and have steeper slopes than warm fronts. The advancing wedge of cold air lifts the lighter warm air mass and produces a relatively narrow band of clouds.

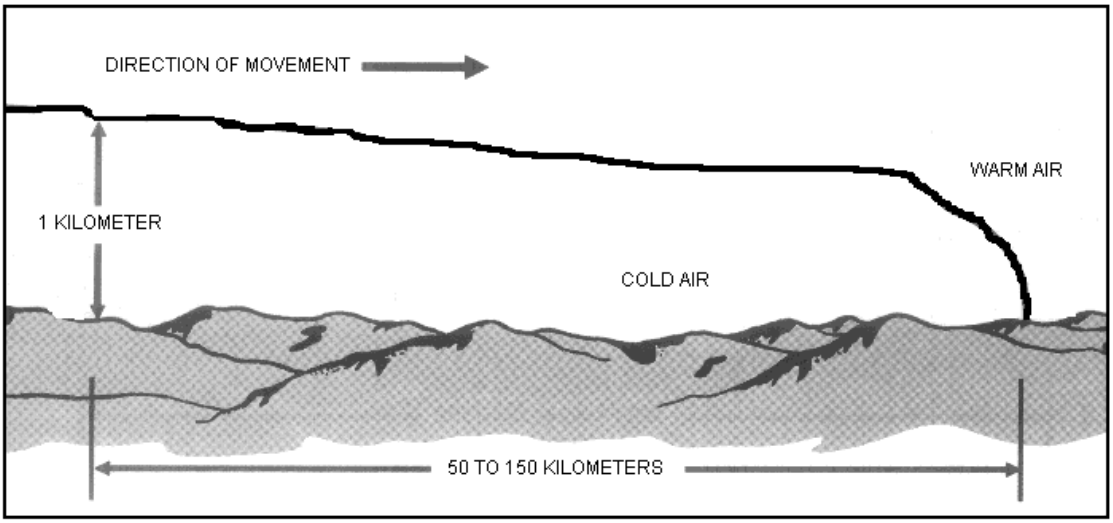


Figure 3-6. Cloud Front

The type of clouds formed by the cold front depends on the properties of the air masses involved and the speed of the frontal system. Fast-moving cold fronts, when lifting moist, unstable air, generate cumuliform clouds that are slightly ahead of the front. A line of thunderstorms that frequently develops parallel to and some distance ahead of rapidly moving cold fronts may have cloud systems that extend to the rear of the surface position of the front. The clouds are mainly stratiform when the warm air is moist and stable. When the warm air is quite dry, little or no cloudiness occurs with the passage of a cold front. At the surface, the passage of a cold front is characterized by:

- An abrupt decrease in temperature.
- A marked shift of surface wind, usually greater than 90°.

- A decrease in moisture content of the air.

- A marked decrease in pressure as the front approaches, followed by a rising pressure after the front passes.

(2) **Warm Front**. When warm air replaces cold air at the surface, it is called a warm front (Figure 3-7). The speed of the advancing warm air is greater than that of the retreating cold air. Therefore, the warm air flows upward over the sloping wedge of dense, cold air. The force of the rising warm air slowly pushes the cold air back. The effect of the earth's surface causes the slope of the warm front to be very flat. The dimensions of a warm front wedge range from 100 to 300 km horizontal distance with an altitude from 0 to 1 km. With the same winds, the speed of a warm front is about half that of a cold front. The clouds associated with a warm front are mainly stratiform and extend well ahead of the surface position of the front. The weather depends largely on the stability and moisture content of the overrunning air. Steady precipitation with low ceiling and limited visibility is normal in advance of warm fronts. At the surface, the passage of a warm front is characterized by:

- A marked increase in temperature.

- A slight shift of surface wind, usually less than 90°.

- An increase in moisture content of the air.

- A decrease in pressure as the front approaches, followed by a leveling off or slowly rising pressure after the front passes.

(3) **Occluded Front**. An occluded front is formed when a cold front overtakes a warm front and forces aloft the warm air that originally occupied the space between the two fronts. There are two types of occlusions: the warm front occlusion (Figure 3-8) and the cold front occlusion (Figure 3-9). The type that will occur depends on whether the cold air of the advancing cold front is colder or warmer than the retreating wedge of cold air in advance of the warm front. However, the essential point in both warm and cold front occlusions is that two cold air masses meet and force the warm air aloft. This causes extensive cloudiness. The weather associated with an occlusion depends on the properties of the three air masses involved.

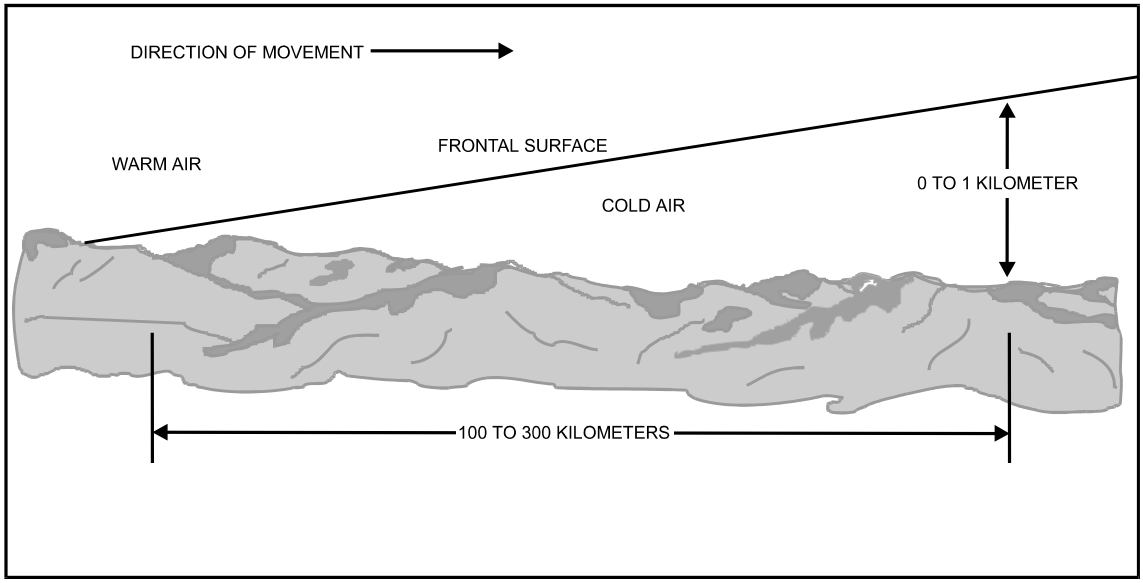


Figure 3-7. Warm Front

(4) **Stationary Front**. On occasion, both warm and cold air masses contain almost equal amounts of energy and neither can move appreciably. During the period when little or no frontal movement takes place, the system is known as a stationary front. The weather associated with a stationary front is quite similar to that with a warm front.

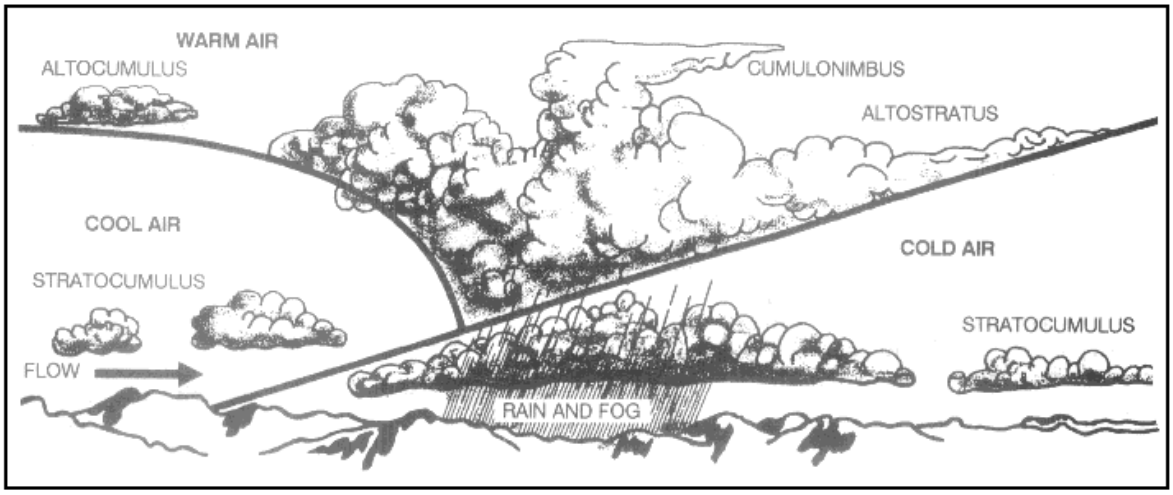


Figure 3-8. Warm Front Occlusion

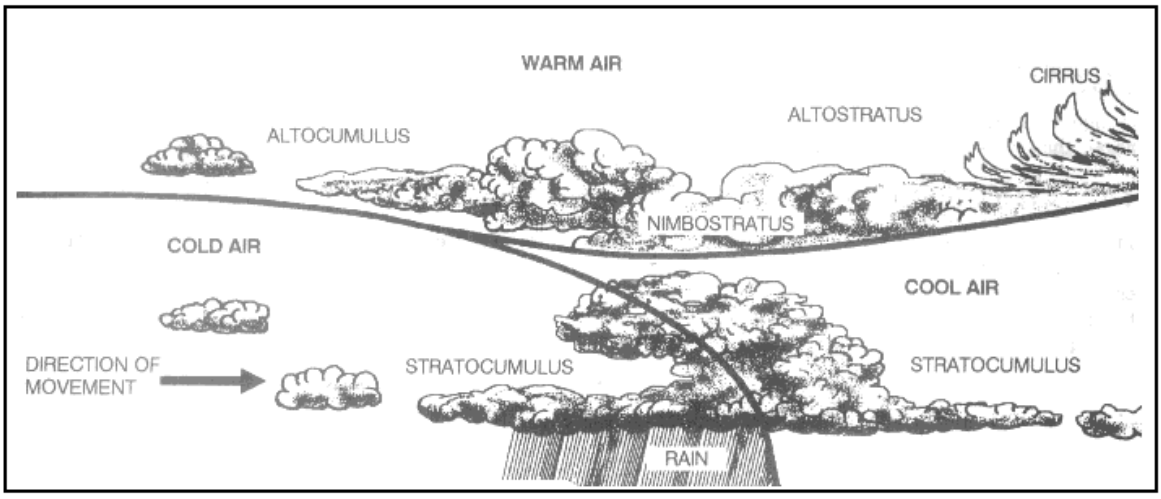


Figure 3-9. Cold Front Occlusion

Section II
Weather as it Applies to the Artillery

This section implements STANAG 4044 and QSTAG 1166.

3-10. FIELD ARTILLERY MET

Field artillery met deals with the techniques and procedures for determining current atmospheric conditions. Atmospheric conditions along the trajectory of a projectile or rocket directly affect its accuracy and may cause the projectile or rocket to miss the desired point of impact. A 5 to 10 percent effect on the firing tables is possible even with stable atmospheric conditions. For example, tests in Southwest Asia have shown that firing artillery at maximum ranges in extreme heat and low air density resulted in met corrections up to 4,700 meters.

Met data are one of the prerequisites for accurate predicted fire. With today's emphasis on first round fire for effect and trends toward longer distances, accurate met corrections for artillery fires are crucial. The use of invalid or no met corrections could cause artillery projectiles to impact on friendly troops. Accurate met data must be obtained and appropriate corrections applied to all fires to:

- Conserve ammunition.
- Decrease time in adjustment.
- Obtain a greater surprise effect.
- Reduce the potential for fratricide.

Despite automation, all met section crew members should have a common understanding of certain atmospheric and ballistic terms and the effects of met conditions on artillery fires. Supervisors also must be able to recognize adverse weather changes that could abruptly negate the accuracy of met messages.

3-11. ATMOSPHERIC TERMS

In addition to the weather-related terms identified earlier in this chapter, there are other atmospheric terms used consistently by the FA met crew member. They are called ballistic terms and are discussed in the following paragraphs.

a. **Standard Atmosphere**. When computing trajectories, ordnance ballisticians use the International Civil Aviation Organization (ICAO) standard atmosphere. This standard atmosphere is the basis for all data of the ballistic solution as well as a point of departure for ballistic met corrections. The ICAO atmosphere at sea level is described as follows:

(1) Dry air.

(2) No wind.

(3) Surface temperature of 15°C with a decrease, or lapse rate, of -6.5°C per 1,000 meters up to a height of 11,000 meters and a constant temperature of -56.5°C between 11,000 and 25,000 meters.

(4) Surface pressure of 1,013.25 mb, decreasing with height.

(5) Surface density of 1,225 grams per cubic meter (gm/m^3), decreasing with height.

b. **Atmospheric Zones**. For convenience in computing, reporting, and applying corrections, the standard atmosphere is further identified by atmospheric zones. The atmospheric zones for various met messages and the thickness and heights of the zones are shown in Table 3-1.

c. **Ballistic Wind**. Ballistic wind is a wind of constant speed and direction that has the same effect on a projectile during its flight as all the varying winds serially encountered by the projectile.

d. **Ballistic Density**. Ballistic density is a constant density, expressed as a percentage of standard density, that has the same effect on a projectile's trajectory as the varying densities serially encountered by the projectile.

e. **Ballistic Temperature**. Ballistic temperature is a constant vertical temperature, expressed as a percentage of standard temperature, that has the same effect on a projectile in flight as the varying temperatures serially encountered by the projectile.

HEIGHT (meters)	LINE (ZONE) NUMBERS				
	COMPUTER	BALLISTIC	TARGET ACQUISITION	SOUND RANGING	FALLOUT
SURFACE	0	0	0	0	0
50	1	1	1	1	1
100			2		
200			3		
300	2	2	4	2	
400			5		
500			6		
600	3	3	7	3	
700			8	4	
800			9		
900			10		
1000			11		
1100	4	4	12		
1200			13		
1300			14		
1400			15		
1500			16		
1600	5	5	17		
1700			18		
1800			19		
1900			20		
2000			21		
2100	6	6	22		2
2200			23		
2300			24		
2400			25		
2500			26		
2600	7		27		
3000					
3500	8	7			
4000	9				
4500	10	8			3
5000	11				
6000	12	9			
7000	13	10			4
8000	14				
9000	15	11			5
10000	16				
11000	17	12			6
12000	18				
13000	19	13			7
14000	20				
15000	21	14			8
16000	22				
17000	23	15			9
18000	24				
19000	25				10
20000	26				
****					****
30000					15

Table 3-1. Atmospheric Structure of Met Message

3-12. MET EFFECTS ON ARTILLERY FIRES

a. **Wind**. The effects of wind on a projectile are easy to understand. A tail wind causes an increase in range, and a head wind causes a decrease in range. A crosswind blows the projectile to the right or left, which causes a deflection error. FDC personnel convert ballistic wind measurements into range and deflection and apply corrections to the deflection and elevation of the artillery piece. Figures 3-10 and 3-11 show the effects of a 20-knot wind on a 155mm howitzer firing at a range of 11,000 meters, charge 7 white bag (WB).

b. **Temperature**. Variations in air temperature cause two separate effects on a projectile. One effect is caused by the inverse variation of density with temperature (equation of state). This effect is compensated for when density effects are considered. The second effect is regarded as the true temperature effect. It is the result of the relationship between the speed of the projectile and the speed of the air compression waves that form in front of or behind the projectile. These air compression waves move with the speed of sound, which is directly proportional to the air temperature. The relationship between the variation in air temperature and the drag on the projectile is difficult to determine. This is particularly true for supersonic projectiles since they break through the air compression waves after they are formed. As firing tables indicate, an increase in air temperature may increase, decrease, or have no effect on achieved range, depending on the initial elevation and muzzle velocity of the weapon. Figure 3-12 shows the effect of a 5-percent deviation from standard temperture.

c. **Density**. Density of the air through which a projectile passes creates friction that affects the forward movement of the projectile. This affects the distance the projectile travels. The density effect is inversely proportional to the projectile ranges; that is, an increase in density causes a decrease in range. Figure 3-13 shows the effect of a 5-percent deviation from the standard air density. Air density decreases rapidly with height. Therefore, the altitude of the firing battery and the ordinate of the trajectory have a direct effect on the magnitude of the density correction. Given equal deviations from standard of each met effect on the flight of a projectile, air density has the greatest range effect.

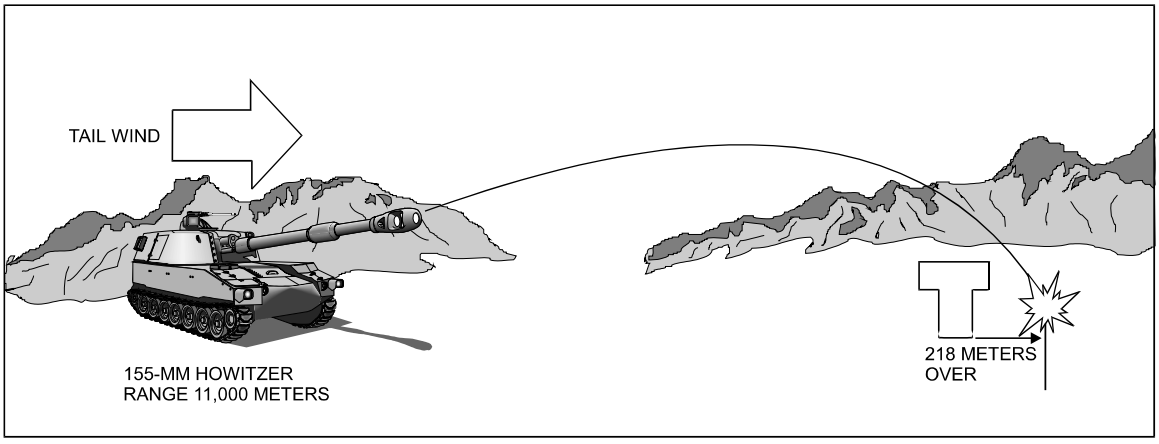


Figure 3-10. Effect of a 20-Knot Tail Wind

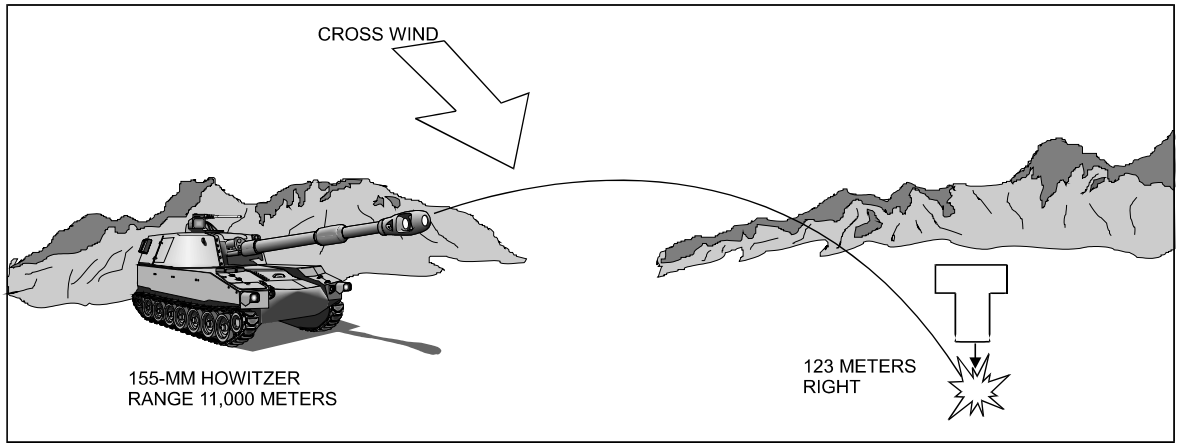


Figure 3-11. Effect of a 20-Knot Crosswind

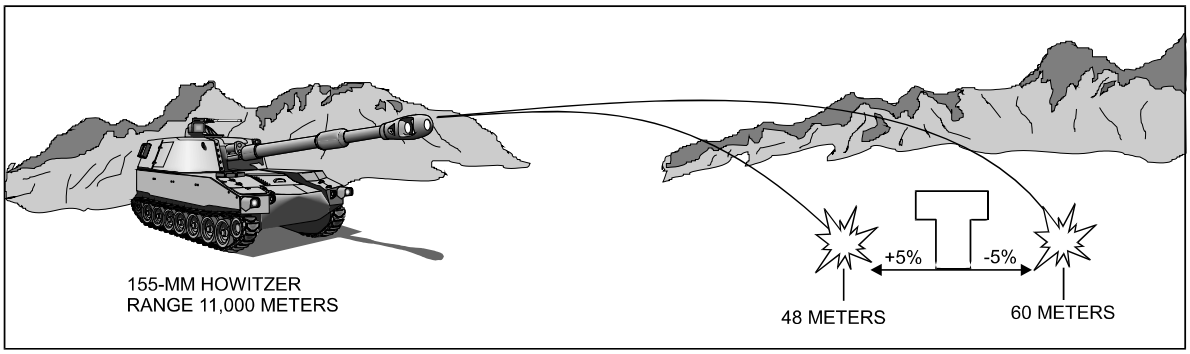


Figure 3-12. Effect of Temperature

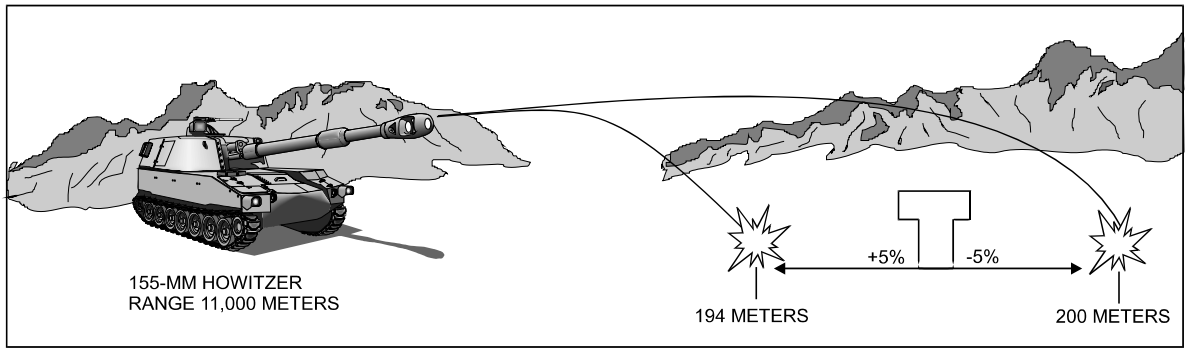


Figure 3-13. Effect of Density

Chapter 4
Operating Principles

Although some met sections have different equipment, the principles of data collection are basically the same with a few exceptions. This chapter discusses these principles and differences beginning with the navigational aid systems and then describes the operating modes.

Section I
MMS and MDS Sections

4-1. NAVAID SYSTEMS

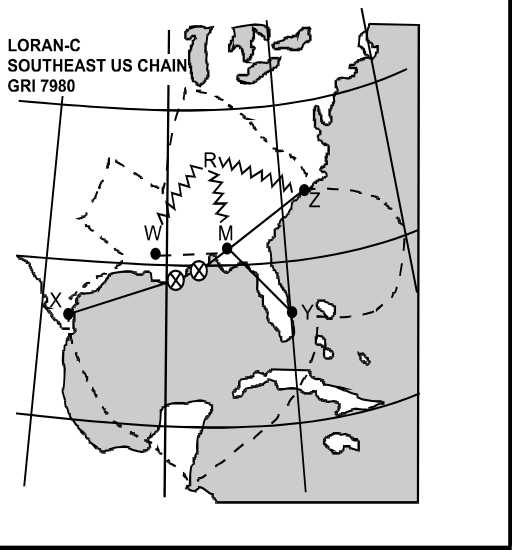
There are three NAVAID systems that produce signals suitable for use by met sections. They are long-range aid to navigation (LORAN), Omega, and very-low frequency (VLF). All three systems operate on the same concept. A NAVAID signal receiver inside a radiosonde in flight receives transmissions from groups of fixed stations. The radiosonde then transmits the NAVAID information to the ground equipment. The differences in the time of arrival of the signal and the phases of the signals are computed by using triangulation to determine the geographical position of the radiosonde.

a. **LORAN**. The LORAN system is an established low-frequency commercial navigational system. The LORAN is the most reliable of the NAVAID systems. The LORAN produces a highly stable ground wave that can be received about 2,000 km from the system transmitters. Ideal atmospheric conditions can extend the range of LORAN system transmitters to 8,000 km.

(1) The LORAN system currently has several operational groups of stations called chains. These chains cover a substantial part of the world's coastal areas. One station of each chain is the primary transmitting station, identified as the master station. The others are secondary stations. The primary and secondary transmitters emit synchronized signals that radiate away from the antenna.

(2) The map at Figure 4-1 represents a LORAN chain in the southeastern part of the United States. It has five transmitting stations. Station M, or Malone, is the primary station. Assume, for example, that a NAVAID radiosonde is operating aloft at point R on the map. The signals received by the radiosonde from stations W, M, and Z arrive at different times. The met system receives and processes these different arrival times. The met system then determines the phase relationship of the signals received from the radiosonde. Finally, the met system converts the information into wind data aloft. A list of LORAN chains is at Appendix F.

b. **Omega**. The Omega system is also a low-frequency navigation system. It requires only six stations for worldwide coverage. Two additional stations are used to enhance the coverage. The system also incorporates stations located in Russia. Since weather does not greatly affect low frequencies, Omega signals may be received up to 9,700 km from the transmitter. Each transmitter in the system transmits once every 10 seconds. An atomic clock controls the accuracy of the starting times for these transmissions. At prescribed times, a given station emits a frequency, momentarily stops, emits a second frequency, stops again, and then emits a third frequency. Each transmission time lasts one second. Timing prevents more than one station from transmitting a given frequency at the same time. The met system determines the location of an Omega-configured radiosonde by comparing the phases of the



LEGEND:
R = Radiosonde X = Raymondville, TX
M = Malone, FL Y = Jupiter, FL
W = Grangeville, LA Z = Carolina Beach, NC

Figure 4-1. Southeast US Chain

signals received. A map indicating locations of Omega stations is at Appendix F.

c. **VLF**. The VLF system uses a group of eight transmitters. Each transmitter operates on a different exact frequency. They operate at very high power and are very reliable. The met system simultaneously processes signals received directly from the VLF transmitters and those transmitted from the radiosonde. It determines the phase relationship of the signals and then computes the location of the radiosonde. The met section can use a combination of VLF and Omega stations. A map indicating location of VLF stations is at Appendix F.

4-2. NAVAID SELECTION

a. The first step in selecting a NAVAID for a met sounding is to determine the geographical coordinates of the met station location.

b. The next step is to select the NAVAID stations that can provide the best coverage (see Appendix F). Operation in the NAVAID mode requires three stations. Ideally, the three stations selected should form the corners of an equilateral triangle, with the met station centered in the triangle. Ideal situations seldom occur. Select the best possible compromise.

c. A local whip antenna receives NAVAID signals directly from the fixed NAVAID transmitters. The final selection step is for the met station leader or met crew member to view the quality of these signals before preparing for a sounding. He selects the best NAVAID system available for operation. The crew member then prepares the radiosonde designed for use with that system.

4-3. NAVAID OPERATIONS

In the NAVAID mode the met section can operate from a fixed location, while on the move, or the section can conduct a remote launch.

a. **Fixed**. Fixed location operations allow the met section to provide continuous met coverage for a particular area of interest.

NOTE: The AN/TMQ-38 equipped section cannot conduct mobile operations as currently configured.

b. **Mobile**. Mobile operations allow a met section to start a NAVAID sounding before moving to another site. The system will continue to process data while the section is moving and messages can be transmitted once the section has stopped in the new location. Mobile operations allow an uninter-rupted sounding schedule. The S3 should consider this capability when planning met section employment.

c. **Remote**. Remote launch allows the section to release balloon-borne radiosondes from a position up to 20 km from the primary section location. Remote launch allows data to be collected close to the area of interest without displacing the entire section. When coordinated properly, this capability can greatly increase the AMV of one section. Limiting factors of remote launch include the following:

- Restrictions imposed by terrain.
- Communications.
- Tactical situations.
- Reception of NAVAID signals.
- Availability of personnel and equipment.

(1) During offensive operations, supported units may move quickly forward out of AMV coverage. Remote launch helps to provide continuous availability of valid met data to rapidly moving artillery units. An example of a routine use of the NAVAID remote launch capability is to deploy a balloon launch team forward with artillery advance parties. The launch team receives commands from the primary section location by radio. On arrival at the remote launch site, the team takes surface measurements and launches the balloon on command of the section headquarters. The launch team may either return immediately to the primary section location, travel to a second remote launch site, or remain at its present location. Figure 4-2 shows a graphic example of remote launch capability.

(2) Each remote launch mission is different and requires extensive planning before execution. The S3 and the met station leader plan remote launches and incorporate them into the met section positioning scheme.

4-4. RDF OPERATIONS

The RDF operating mode is designed to be used whenever NAVAID systems are unavailable. It only operates from a fixed location. A ground device tracks the path of a radiosonde as it rises in the atmosphere. Angular and meteorological data are passed on to the equipment shelter for processing and dissemination.

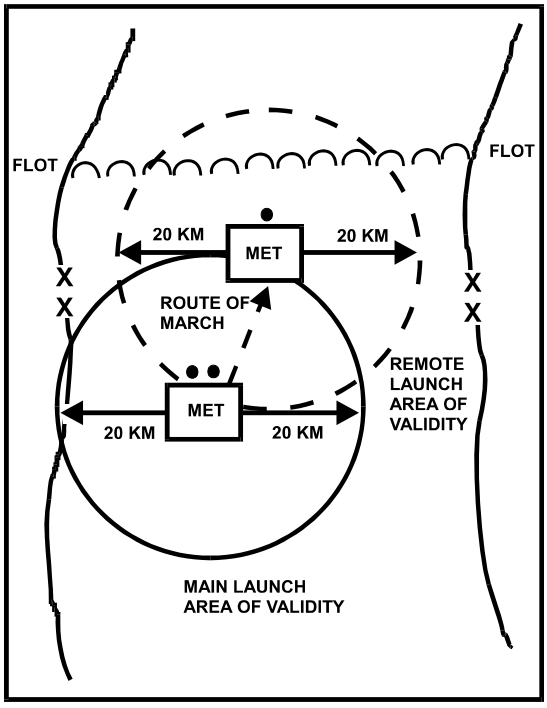


Figure 4-2. Remote Launch Capability

Section II
MDS Section Only

4-5. MIXED MODE

In the mixed operating mode, the theodolite is used along with VLF and/or Omega. The VLF and/or Omega signals travel more than 9,000 km from their sources. These great distances and the curvature of the earth can cause VLF and/or Omega signals to be interrupted or received erratically near the earth's surface, particularly in mountainous terrain. This inferior signal reception can cause invalid positional data. To overcome this problem, the theodolite operator tracks the radiosonde during the first 1,600 meters of its ascent. After the radiosonde reaches 1,600 meters in altitude, the theodolite operator stops tracking the balloon and the system processing unit (SPU) uses only the data provided by the NAVAID antenna system.

4-6. PIBAL MODE

The PIBAL mode is used only when NAVAID systems are unavailable and the RDF is not operational. In the PIBAL operating mode, angle readings are obtained by tracking a pilot balloon while the air data are determined by using the standard atmospheric table. In the NAVAID and RDF modes, the actual readings are taken from the sounding. Sightings taken in the PIBAL mode are not as reliable and are limited by cloud ceiling. For this reason, use PIBAL operations only as a backup operating mode.

4-7. OFF-LINE MODE

The off-line mode provides for internal review or transmission of previously received met data soundings. The off-line operating mode is part of post flight procedures in which the operator retrieves previously recorded flight data from a data tape cartridge. The operator can either transmit the met messages developed from the flight, print out the raw data from the previous flight for review, or print out the tables associated with each zone.

Chapter 5
Meteorological Data System, AN/TMQ-31

This chapter discusses the components, site considerations, and personnel of the meteorological data system section.

Section I
Meteorological Data System Equipment

The MDS is an automated meteorological data processing system. The MDS contains two main equipment groups, the shelter group and the RDF group. This section discusses the MDS and additional equipment. Figure 5-1 shows the MDS equipment.

5-1. SHELTER EQUIPMENT GROUP

The shelter equipment group contains the equipment needed to receive and process met data transmitted by a radiosonde. The shelter equipment group consists of the systems described below.

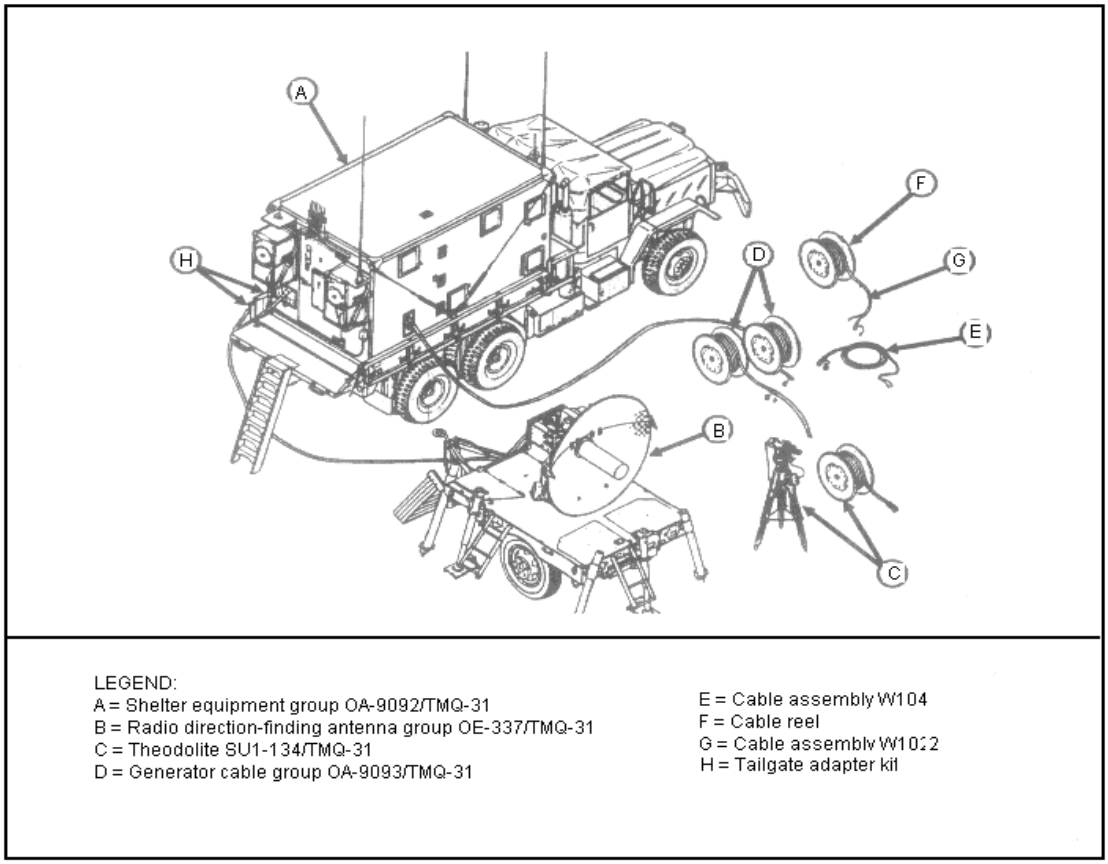


Figure 5-1. MDS Equipment

a. **NAVAID Antenna System**. When the MDS operates in the NAVAID mode, the NAVAID antennas receive signals from one of the following NAVAIDS:

- LORAN.
- Omega.
- VLF.

b. **Receiving System**. The receiving system converts, amplifies, and reproduces signals from the NAVAID, RDF antenna, or the theodolite and passes this data to the SPU.

c. **System Processing Unit**. The SPU receives and processes met data and position information. It formats the data into met messages for transmission to using units.

d. **Communication System**. This system receives met messages from the SPU, encodes or encrypts, and transmits to subscribers. It also receives and acknowledges digital messages.

e. **Page Printer**. This printer provides a hard copy record of all met messages.

f. **Power Supply System**. The MDS operates from 120- and/or 240-volts alternating current (v AC) and can perform limited operations using a 28-volts direct current (v DC) power source. A 60-hertz inverter and a 28-v DC power supply convert the supplied power to the correct voltage for operating the equipment. The RDF and air conditioners operate only when AC power is used.

5-2. RADIO DIRECTION FINDING EQUIPMENT GROUP

The RDF is a trailer-mounted, pedestal-based antenna system that automatically tracks the position of a radiosonde in the atmosphere. It receives met data from the radiosonde and detects position information used for wind computation. The RDF passes this data to the shelter equipment for processing and dissemination.

5-3. THEODOLITE

The theodolite is a tripod-mounted, dual-telescope, optical-electrical device that can be used in VLF and Omega modes to obtain radiosonde position information. It also can find and track a PIBAL. It consists of a junction box and a power cable. The junction box receives 115 v AC from the shelter and distributes it to the theodolite synchros. It also routes azimuth and elevation data from the synchros back to the shelter for processing. The 200-foot power cable carries power to the theodolite and carries azimuth and elevation data back to the system for processing.

5-4. GENERATOR CABLE EQUIPMENT

The generator cable equipment provides primary AC operating power to the MDS. It consists of two interchangeable 100-foot cables to connect the generator trailer or a commercial power source to the shelter AC power entrance panel. A third cable (10 feet long) makes the connection between the generator output lugs and the cables. Two cable reels are provided for housing the cables on the deck of the generator trailer.

5-5. ASSOCIATED EQUIPMENT

a. **Radiosonde**. The radiosonde is a small electronic instrument. A free-flight balloon carries it aloft. The radiosonde transmits pertinent weather data from aloft to the met section. The radiosonde senses pressure, temperature, and relative humidity. The MDS uses different types of radiosondes depending on the operating mode selected for the planned sounding.

b. **Power Equipment**. The MDS can operate either from vehicle power or from an external power source. When performing mobile operations, the power needed to operate the MDS is supplied by the vehicle on which it is mounted. When the air conditioners are on or when the MDS is operating in the RDF operating mode, an external source of power is required. A trailer-mounted power plant is towed by one of the section's vehicles to provide that power.

5-6. COMMUNICATIONS EQUIPMENT

a. **Radios**. The met section is authorized SINCGARS. They are used for communi-cation with met users and command and control.

b. **Remote Data Terminal**. The remote data terminal (RDT) is a two-way interface device for receiving and routing digital communica-tions between the MDS and remote users.

c. **Digital Nonsecure Voice Terminal**. This telephone with associated wire connections is a mobile subscriber equipment (MSE) device that allows for voice and digital communi-cations. The digital nonsecure voice terminal (DNVT) provides access to the common user area communications network.

d. **Local Control Radio Set**. This radio provides communications between the equipment operator and the balloon launch team during release.

5-7. VEHICULAR EQUIPMENT

Each section is authorized three 5-ton vehicles with trailers. Additionally, each section is authorized a 1 1/4-ton truck high-mobility multipurpose wheeled vehicle (HMMWV). The three 5-ton vehicles are essentially the same. However, the vehicle transporting the equipment shelter is slightly modified by adding a 100 amperes (amp) kit. Each vehicle is the drop-side model of the 5-ton diesel cargo vehicle. Vehicle one transports the equipment shelter that serves as the operations shelter. It tows the RDF trailer. Vehicle two tows the electric power plant and transports and stores MDS components and supplementary equipment. Vehicle three tows the water trailer and transports the balloon inflation and launching equipment and expendable supplies. Section IV contains example load plans.

5-8. MET STATION MANUAL, AN/TMQ-4A

a. The met station manual, AN/TMQ-4A, consists of the following:

- Surface observation equipment.
- Balloon inflation equipment.
- Miscellaneous minor components required to support the operation of the MDS.

b. The purpose and use of each item of equipment are described in Technical Manual (TM) 11-6660-218-12.

Section II
Meteorological Data System Section Site Operations

5-9. SITE SELECTION

Met sections are positioned by the S3 and met station leader to provide the best possible area of coverage and most valid met data. Section deployment depends largely on the location of firing units, targets, terrain, and weather. When selecting a MDS site, the met station leader must weigh the following considerations:

- Safety.
- Tactical situation.
- Weather forecast and prevailing winds.
- Availability of NAVAID signals.
- Security.
- Communications modes and nets.
- Operating frequencies.
- Electronic warfare activities.
- Areas of coverage.
- Terrain.
- Availability of adequate supply of water.
- Logistical support.
- Unit attachment.

5-10. SURVEY REQUIREMENTS

This paragraph implements QSTAG 1166.

The met station leader conducts a ground reconnaissance to determine the exact positions for major items or groups of MDS equipment. Once this is done, he selects two reference points to facilitate orienting the RDF to true north when it is emplaced. Reference points should be fixed, easily identified objects, such as a tall pole or the fork of a large tree.

a. **Survey Available**. The MDS is emplaced to fifth-order accuracy or with the global positioning system (GPS). The survey section will provide the met section with the latitude, longitude, and height of the met section. The supporting survey section should also provide angles to the reference points.

b. **Survey Not Available**. If survey support is not available, the met station leader determines angles to the two reference points. The remaining required data are read from an area map. The map datum is World Geodetic System 84.

5-11. RADIO DIRECTION FINDING GROUP EMPLACEMENT

The RDF cannot be emplaced more than 200 feet from the equipment shelter due to cable length. The RDF should be placed on reasonably level terrain. It should not be screened by large obstacles that may interfere with signal reception. The position selected for the RDF must have a clear area downwind to observe balloon release. There must be no tall objects to obstruct line of sight from the RDF to a radiosonde in flight. Once the RDF trailer is disconnected from the vehicle that tows it, the vehicle is moved into a concealed area.

5-12. SHELTER EQUIPMENT GROUP EMPLACEMENT

The met station leader positions the equipment shelter on firm, level ground. The shelter must not be positioned more than 200 feet from the RDF or power equipment due to cable length. The shelter should not be positioned under power lines.

5-13. POWER EQUIPMENT EMPLACE-MENT

Power equipment must be placed within 200 feet of the shelter due to cable length. Ideally, the power equipment should be placed downwind from the shelter to reduce noise in the shelter. Once the power equipment trailer is disconnected from the vehicle that tows it, the vehicle is moved into a concealed area.

5-14. BALLOON INFLATION SITE LOCATION

NOTE: If the section uses hydrogen gas for inflation, special safety and environmental protection measures are required. See Appendix H for more information.

Upon entering the AO, the vehicle towing the water trailer moves to the balloon inflation site. The water trailer is disconnected on reasonably flat terrain, the balloon inflation and launching equipment are unloaded, and the vehicle is moved into a concealed area. The inflation site should be downwind of the equipment shelter, RDF, and theodolite positions if possible.

5-15. THEODOLITE EMPLACEMENT

NOTE: The theodolite is a precision optical-electrical instrument subject to damage from weather elements. It is emplaced only when operations require its use.

Emplace the theodolite on firm, level ground. Cable length prevents positioning more than 200 feet from the shelter. Area downwind should be free of objects extending above 3 degrees of the horizon. Figure 5-2 provides an example of a site occupation.

5-16. CAMOUFLAGE

The modules of radar-scattering camouflage in Table 5-1 are required for camouflaging the system. Camouflage procedures below are used. See TM 5-1080-200-13&P for detailed information.

The section should--

- Install camouflage nets when the RDF trailer is emplaced.

- If the shelter is not concealed by natural camouflage, camouflage it when the position is occupied.

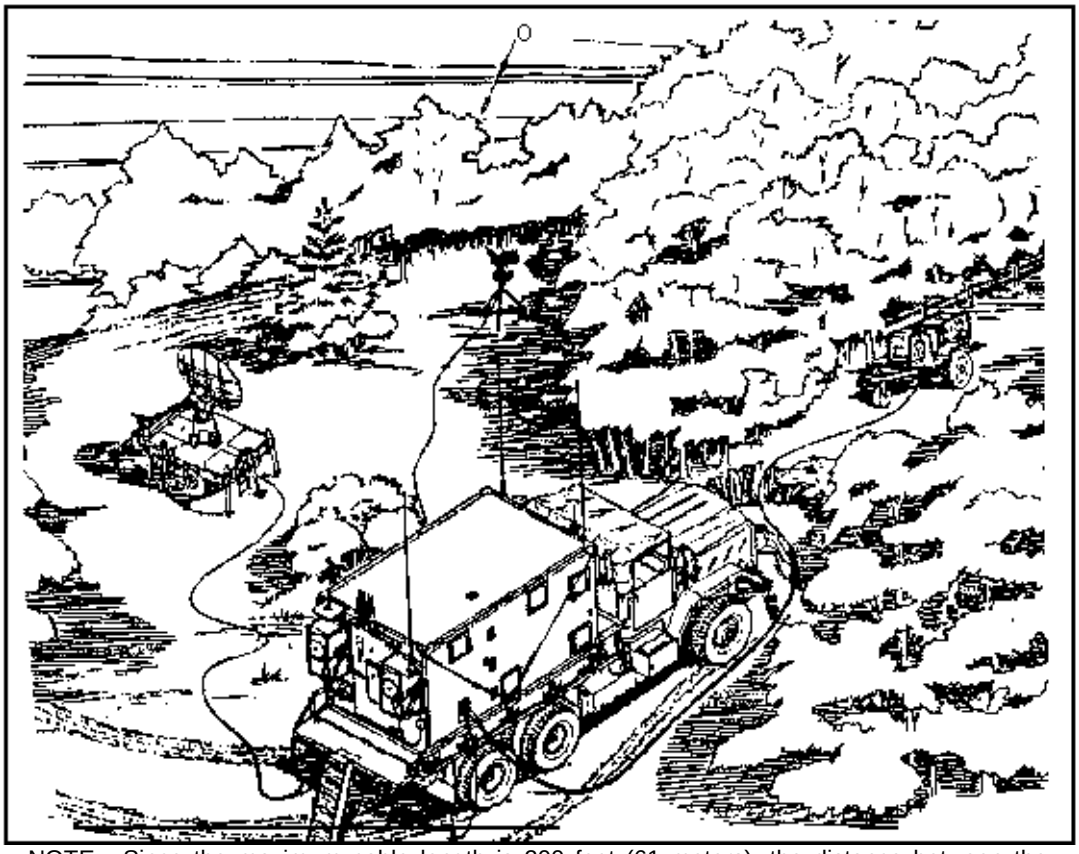
- After immediate camouflage requirements are complete, continue site improvements as the met mission allows.

5-17. DISPLACEMENT PROCEDURES

Commanders relocate met sections to maintain met support. Therefore, crew members must be trained for mobility and must be able to displace, move, and occupy a new site rapidly during critical periods of the battle. The met station leader informs the S3 when the validity of the last message from the current position will expire and how much time is required to march-order the section. He recommends the best time to make the displacement and a course of action to relay met data from adjacent sections while displacing. The met station leader's briefing of section personnel before each displacement should include, as applicable, the following:

- Broadcast time of the last met message from the current position.

- Broadcast time of the first met message from the next position.



NOTE: Since the maximum cable length is 200 feet (61 meters), the distance between the shelter and its interfacing equipment cannot exceed the following distances:

- Shelter to RDF trailer: 200 feet (61 meters) maximum
- Shelter to generator trailer: 200 feet (61 meters) maximum
- Shelter to remote antenna mast: 200 feet (61 meters) maximum
- Shelter to theodolite: 200 feet (61 meters) maximum

Figure 5-2. Site Occupation

- Procedures for monitoring, copying, and transmitting of met data from adjacent met sections on both the left and right flanks. Supported units will choose the message from their nearest met section.

- Section march-order sequence and when the camouflage systems will be dropped, packed, and loaded.

- Departure time and/or whether the section has road clearance to move independently.

- Where the met vehicles will be positioned in the battery column.

- Route of march and any significant landmarks.

- Designation of the section representative on the reconnaissance party.

- Availability of water at the next location and whether road conditions permit moving a partially filled water trailer. (If planned departure time permits, the water trailer should be filled.)

EQUIPMENT	MODULES
5-ton truck, with S-280	3
5-ton truck (2 each)	4
1 1/4-ton truck (HMMWV)	2
RDF trailer	2
Antenna (remote tripod)	1
Water trailer	1
Power plant	1
Tent	2

Table 5-1. Radar Scattering Canouflage Modules

Section III
Meteorological Data System Section Personnel

TITLE	MOS	RANK	
Met station leader	93F40	SFC	1
FA met section sergeant	93F30	SSG	1
FA met crew member	93F20	SGT	1
FA met crew member-repairer	93F20H1	SGT	1
FA met crew member-repairer	93F10H1	SPC	1
FA met crew member	93F10	SPC	1
FA met crew member	93F10	PFC	2
		TOTAL	8

LEGEND:
SFC = SERGEANT FIRST CLASS SGT = SERGEANT PFC = PRIVATE FIRST CLASS
SSG = STAFF SERGEANT SPC = SPECIALIST

Table 5-2. MDS Section Personnel

5-18. MET STATION LEADER (SFC, MOS 93F40)

He will--

- Help the S3 prepare the met plan.
- Advise the S3 on the employment and operation of the met assets within the AO.
- Supervise met section operations.
- Coordinate with the S4 for logistical support.
- Coordinate with the signal staff officer to prioritize means of communication and dissemination of messages.
- Perform site selection and location.
- Direct the operation, emplacement, and displacement of the met section.
- Maintain quality control of met data. Submit necessary reports and maintain a flight log showing the following:
  - Dates.
  - Location.
  - Flight number.
  - Expendables consumed.
  - Other pertinent information.
- Retain the flight log and copies of messages in accordance with Army Regulation (AR) 25-400-2.

- Advise the S3 on all factors affecting mission capabilities, such as personnel, maintenance, and logistics.

- Review, consolidate, and prepare technical, personnel, and administrative reports covering met section and station activities.

- Organize and supervise the met section training program.

- Supervise operator maintenance of met, communications, and vehicular equip-ment.

- Supervise preparation and distribu-tion of all met messages.

- Ensure adherence to safety procedures during balloon inflation and launching.

- Manage met section logistics for repair parts and expendable items.

- Assign personnel to met teams.

- Instruct and lead crew members in met procedures.

5-19. FIELD ARTILLERY MET SECTION SERGEANT (SSG, MOS 93F30)

He will--

- Provide leadership and technical guidance to subordinate personnel.

- Serve as off-shift senior sergeant during periods of extended operation.

- Check data and records.

- Examine data samples for quality control.

- Inspect grounding equipment.

- Decode wind messages.

5-20. FIELD ARTILLERY MET CREW MEMBER (SGT, MOS 93F20)

He will--

- Supervise the second shift during 24-hour operations.

- Ensure communications are main-tained to all users.

- Perform administrative duties as required.

5-21. FIELD ARTILLERY MET CREW MEMBER-REPAIRER (SGT, MOS 93F20H1)

He will--

- Operate met equipment on assigned shift.

- Perform unit maintenance on the section met equipment.

- Operate organic communications equipment.

5-22. FIELD ARTILLERY MET CREW MEMBER-REPAIRER (SPC, MOS 93F10H1)

He will--

- Operate met equipment on assigned shift.

- Perform organizational maintenance on equipment.

- Drive vehicle.

5-23. FIELD ARTILLERY MET CREW MEMBER (SPC, MOS 93FIO)

He will--

- Operate met equipment on assigned shift.

- Prepare balloon train.
- Drive vehicle.

5-24. FIELD ARTILLERY MET CREW MEMBER (PFC, MOS 93F10)

He will--

- Operate met equipment on assigned shift.
- Help prepare balloon train.
- Drive vehicle.

Section IV
Suggested Load Plans

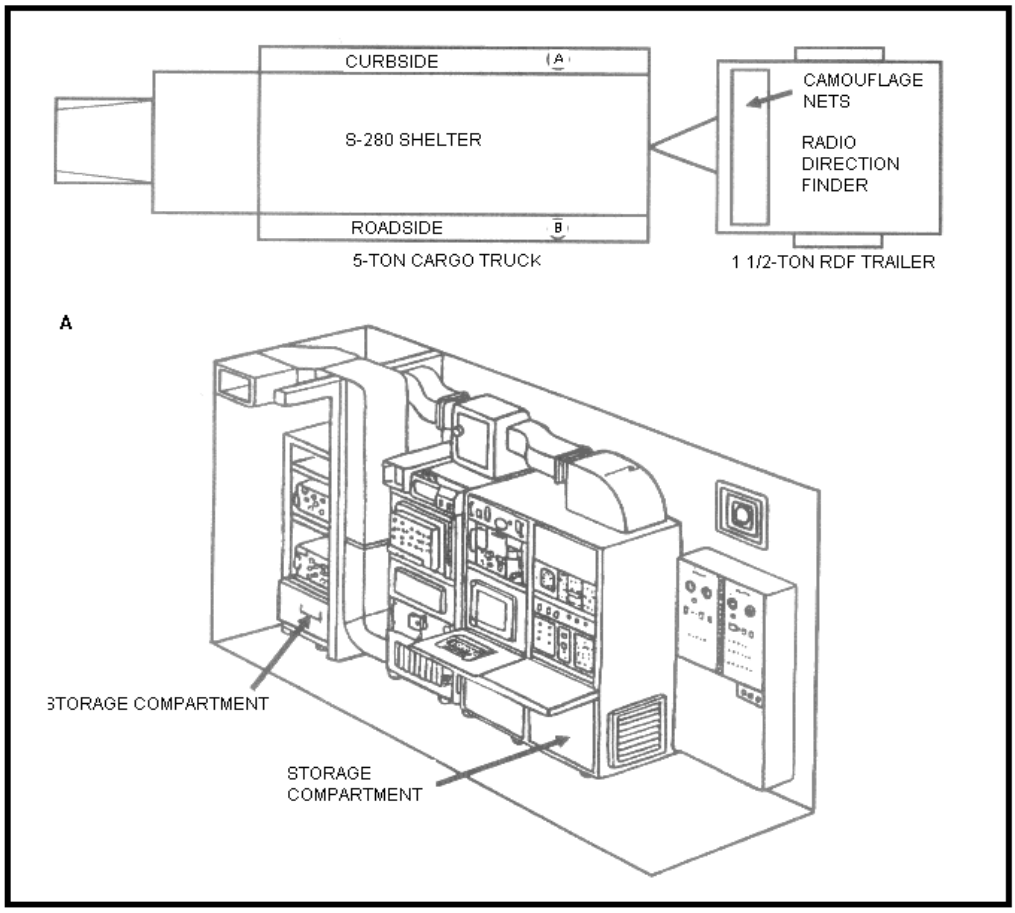


Figure 5-3(A). Vehicle One with Trailer

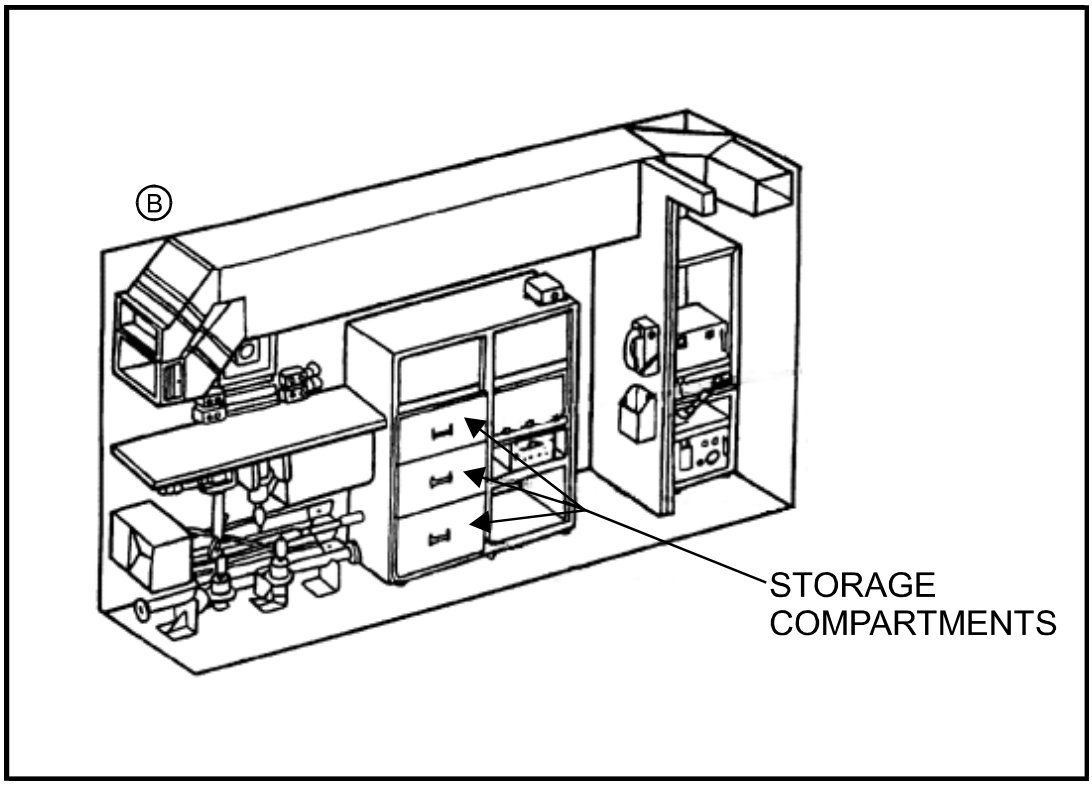


Figure 5-3(B). Vehicle One with Trailer (continued)

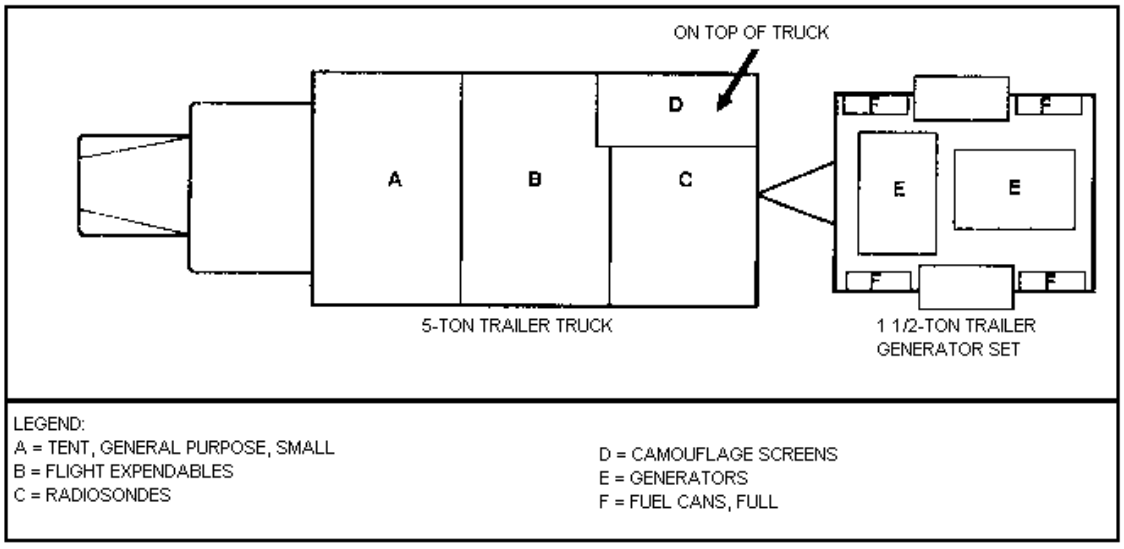


Figure 5-4. Vehicle Two with Trailer

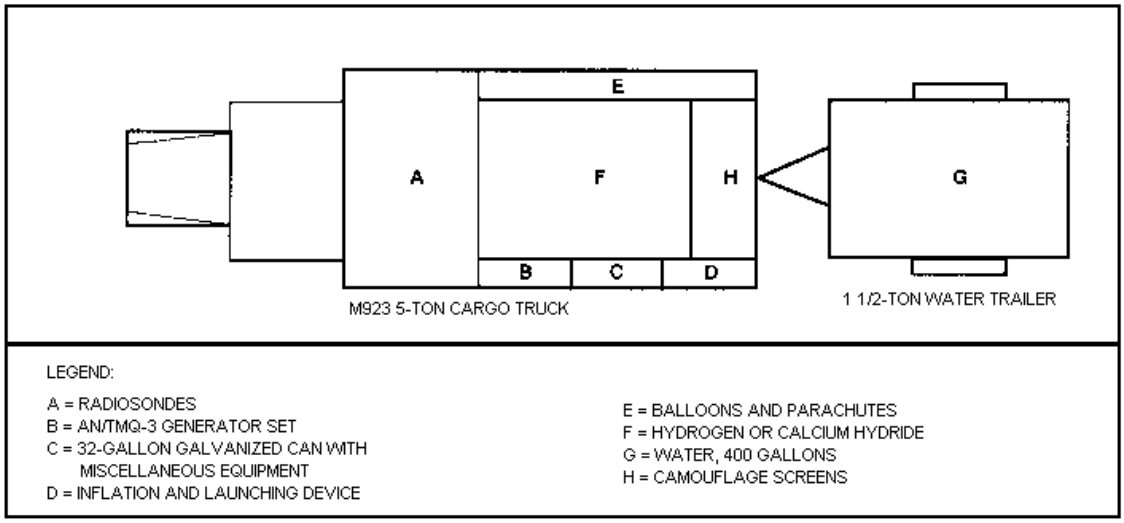


Figure 5-5. Vehicle Three with Trailer

Chapter 6
Meteorological Measuring Set, AN/TMQ-38

This chapter discusses the components, site considerations, and personnel of the AN/TMQ-38 section.

Section I
MMS AN/TMQ-38 Equipment

The AN/TMQ-38 is an automated meteorological data processing system. It consists of two main groups, the main equipment group and the RDF equipment group. This section discusses the AN/TMQ-38 and additional equipment. Figure 6-1 shows the AN/TMQ-38 equipment.

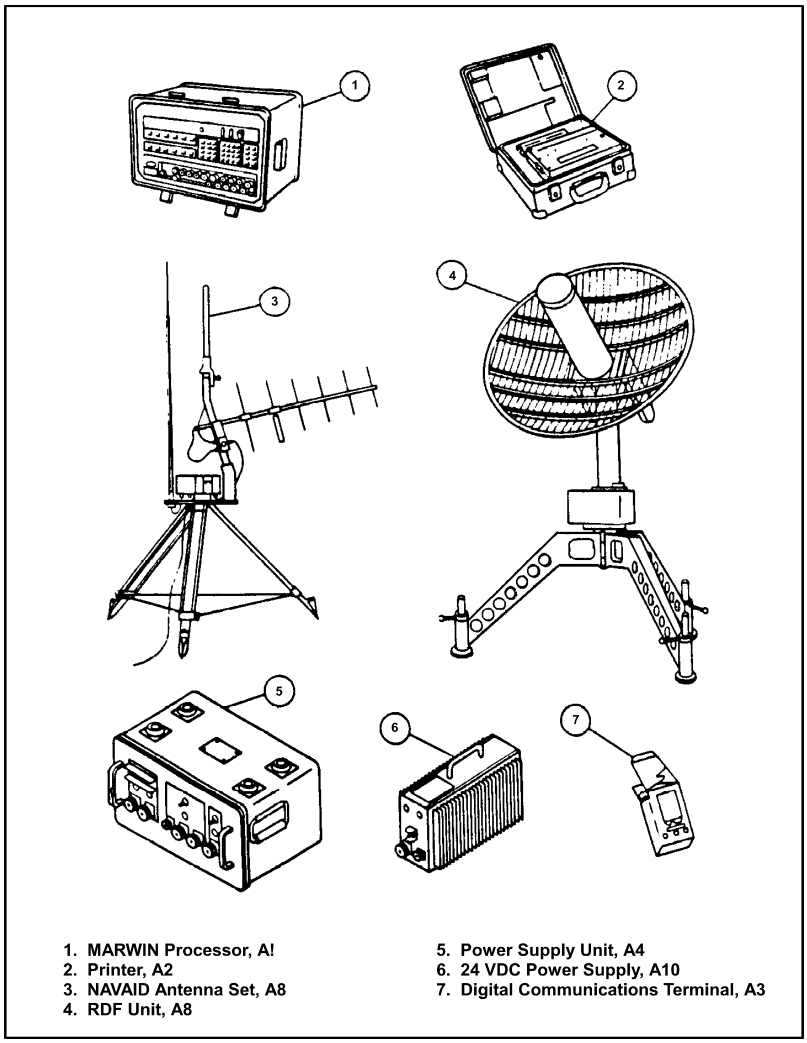


Figure 6-1. AN/TMQ-38 Equipment

6-1. MAIN EQUIPMENT GROUP

NOTE: The AN/TMQ-38 is not housed in a permanent shelter. Met sections must position

the main system group in a temporary shelter, tent, or in the back of a cargo vehicle during operation.

The main equipment group contains the equipment necessary to receive and process met data transmitted by a radiosonde. The main equipment group consists of the systems described below.

a. **NAVAID Antenna System.** When the AN/TMQ-38 operates in the NAVAID mode, the NAVAID antennas receive signals from one of the following NAVAIDS:

- LORAN.
- Omega.
- VLF.

b. **Receiving System**. The receiving system converts, amplifies, and reproduces signals from the NAVAID and RDF antennas and passes this data to the MARWIN processor.

c. **MARWIN Processor**. The MARWIN receives and processes met data and position information. It formats the data into met messages for transmission to using units.

d. **Communication System**. This system receives met messages from the MARWIN, encodes or encrypts, and transmits to subscribers. It also receives and acknow-ledges digital messages.

e. **Page Printer**. The printer provides a hard copy record of all met messages.

f. **Power Supply System**. The AN/TMQ-38 operates from either 120 v AC or +28 v DC primary input power. The power supply unit and the 24 v DC power supply convert the supplied power to the correct voltage for operating the equipment. The RDF operates only when AC power is used.

6-2. RDF EQUIPMENT GROUP

The RDF is a tripod-mounted antenna system that automatically tracks the radiosonde in the atmosphere. It receives met data from the radiosonde and detects position information used for wind computation. The RDF passes the met and position data to the main system group for processing and dissemination. A hand-held Control Display Unit (CDU), con-nected to the antenna by cable, allows for manual control of both the positioning system and the receiver tuning circuit.

6-3. POWER CABLE EQUIPMENT

The power cable equipment provides operating power to the system. It consists of two 50-foot cables to connect an AC power source to the power supply unit. A third ca-ble provides for connecting the power supply unit to a DC power source. These cables are stored in the power supply unit case.

6-4. ASSOCIATED EQUIPMENT

NOTE: The AN/TMQ-38 does not use digital radiosondes.

a. **Radiosonde**. The radiosonde is a small electronic instrument. A free-flight balloon carries it aloft. The radiosonde transmits pertinent weather data from aloft to the met section. The radiosonde senses pressure, temperature, and relative humidity. The AN/TMQ-38 uses different types of radio-sondes depending on the operating mode selected for the planned sounding.

b. **Power Equipment**. The AN/TMQ-38 can operate from vehicle power or an external source. When operating in the RDF mode, an external source of AC power is required. A trailer-mounted power plant is towed by one of the section's vehicles to provide that power.

6-5. COMMUNICATIONS EQUIPMENT

a. **Radios**. The met section is authorized SINCGARS. They are used to communicate with met users and for command and control purposes.

b. **Digital Communication Terminal**. The Digital Communication Terminal (DCT) is a two-way interface device used for receiving and routing digital communications between the met section and remote users.

c. **Digital Nonsecure Voice Terminal**. This telephone, with associated wire connections, is a MSE that allows for voice and digital communications. The DNVT provides access to the common user area communications network.

6-6. VEHICULAR EQUIPMENT

Each section is authorized three HMMWVs. The three vehicles are essentially the same; however, one has been modified by adding a winch. Vehicle one transports the system equipment. Vehicle two carries inflation and launching equipment along with additional supplies. Vehicle three carries supplementary equipment and tows the trailer containing the power plant. Section IV provides example load plans.

6-7. MET STATION MANUAL, AN/TMQ-4B

The met station manual, AN/TMQ-4B, consists of the following:

- Surface observation equipment.
- Balloon inflation equipment.
- Miscellaneous minor components to support the operation of the AN/TMQ-38.

Section II
AN/TMQ-38 Section Site Operations

6-8. SITE SELECTION

Met sections are positioned by the S-3 and met station leader to provide the best possible area of coverage and most valid met data. Section deployment depends largely on the location of firing units, targets, terrain, and weather. When selecting a site, the met station leader must weigh the following considerations:

- Safety.
- Tactical situation.
- Weather forecast and prevailing winds.
- Availability of NAVAID signals.
- Security.
- Communications modes and nets.
- Operating frequencies.
- Electronic warfare activities.
- Areas of coverage.
- Terrain.
- Availability of adequate supply of water.
- Logistical support.
- Unit attachment.

6-9. SURVEY REQUIREMENTS

This paragraph implements QSTAG 1166.

The met station leader conducts a ground reconnaissance to determine the exact positions for major items or groups of equipment. Once this is done, he selects two reference points to

facilitate orienting the RDF to true north when it is emplaced. Reference points should be fixed, easily identified objects, such as a tall pole or the fork of a large tree.

a. **Survey Available**. The met station leader emplaces the section to fifth-order accuracy or with the GPS. The survey section will provide the met section with the latitude, longitude, and height of the met section.

b. **Survey Not Available**. If survey support is not available, the met station leader determines station altitude and location from an area map. The map datum is World Geodetic System 84.

6-10. RDF GROUP EMPLACEMENT

NOTE: If the soundings are to be performed in the NAVAID mode, the RDF is not assembled.

The RDF cannot be emplaced more than 100 feet from the processing equipment site due to the cable length. The RDF should be placed on reasonably level terrain. It should not be screened by large obstacles that may interfere with signal reception. The position selected for the RDF should have a clear area downwind to observe balloon release. There must be no tall objects to obstruct line of sight from the RDF to a radiosonde in flight.

6-11. MAIN EQUIPMENT GROUP EMPLACEMENT

The met station leader positions the main equipment, MARWIN processor, power supply unit, printer, and the DCT in an improvised shelter on firm level ground. The position cannot be more than 100 feet from the RDF or power equipment. The NAVAID antennas should be positioned as described above for the RDF.

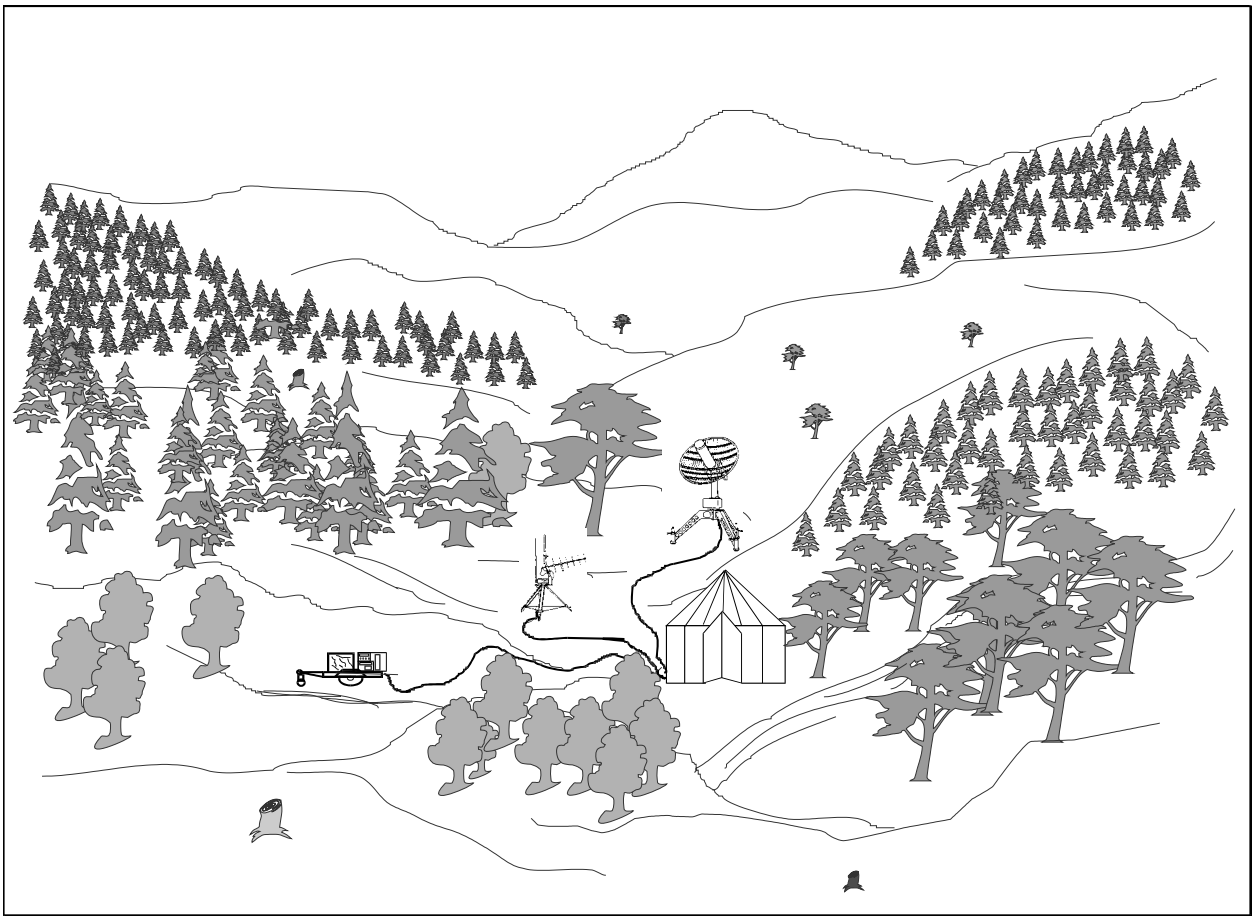
6-12. POWER EQUIPMENT EMPLACEMENT

Power equipment must be placed within 100 feet of the main equipment group due to cable length. Ideally, the power equipment should be placed downwind to reduce noise at the operation site. Once the power equipment trailer is disconnected from the vehicle that tows it, the vehicle is moved into a concealed area.

6-13. BALLOON INFLATION SITE LOCATION

NOTE: If the section uses hydrogen gas for inflation, special safety and environmental protection measures are required. See Appendix H for more information.

Upon entering the AO, the vehicle transporting the balloon inflation and launching equipment moves to the inflation site. The necessary equipment is unloaded, and the vehicle is moved into a concealed area. The inflation site should be downwind of the operation site and RDF positions whenever possible. Figure 6-2 provides an example of a site occupation.



NOTE: Since the maximum cable length is 100 feet (30 meters) the distance between the operation site and its interfacing equipment cannot exceed this distance:

- Operation site to RDF, 100 feet (30 meters) maximum.
- Operation site to generator, 100 feet (30 meters) maximum.
- Operation site to NAVAID antenna set 100 feet (30 meters) maximum.

Figure 6-2. Site Occupation

6-14. CAMOUFLAGE

The modules of radar-scattering camouflage in Table 6-1 are required for camouflaging the system. Camouflage procedures are outlined in TM 5-1080-200-13&P.

EQUIPMENT	MODULES
1 1/4-ton truck (3 each)	6
1/4-ton trailer w/generator (1 each)	2
RDF	1
NAVAID antenna set	1
Tent	2

Table 6-1. Radar Scattering Camouflage Modules

6-15. DISPLACEMENT PROCEDURES

Commanders move met sections as needed to maintain met support. Therefore, crew members must be trained for mobility and must be able to rapidly displace, move, and occupy a new site during critical periods of the battle. The met station leader informs the S3 when the validity of the last message from the current position will expire and how much time is required to march-order the section. He recommends the best time to make the displacement and recommends a course of action to relay met data from adjacent sections while displacing. The met station leader's briefing to section personnel before each displacement should include, as applicable, the following:

- Broadcast time of the last met message from the current position.
- Broadcast time of the first met message from the next position.
- Procedures for monitoring, copying, and transmitting met data from adjacent met sections on both the left and right flanks. Supported units will choose the message from their nearest met section.
- Section march-order sequence and when the camouflage systems will be dropped, packed, and loaded.
- Departure time and/or whether the section has road clearance to move independently.
- Where the met vehicles will be positioned in the battery column.
- Route of march and any significant landmarks.
- Designation of the section representative on the reconnaissance party.

Section III
AN/TMQ-38 Section Personnel

TITLE	MOS	RANK	
Met station leader	93F40	SFC	1
FA met section sergeant	93F30	SSG	1
FA met equipment repairer	93F20H1	SGT	1
FA met equipment repairer	93F10H1	SPC	1
FA met crew member	93F10	SPC	1
FA met crew member	93F10	PFC	1
		TOTAL	6

LEGEND:
SFC = SERGEANT FIRST CLASS SPC = SPECIALIST
SSG = STAFF SERGEANT PFC = PRIVATE FIRST CLASS
SGT = SERGEANT

Table 6-2. AN/TMQ-38 Section Personnel

6-16. MET STATION LEADER (SFC, MOS 93F40)

The met station leader will--

- Help the S3 prepare the met plan.
- Advise the S3 on the employment and operation of met assets within the AO.
- Supervise met section operations.
- Coordinate with the S4 for logistical support.
- Coordinate with the signal staff officer to prioritize means of communication and dissemination of messages.
- Perform site selection and location.
- Direct the operation, emplacement, and displacement of the met section.
- Maintain quality control of met data. Submit necessary reports, and maintain a flight log showing the following:
  - Dates.
  - Location.
  - Flight number.
  - Expendables consumed.
  - Other pertinent information.
- Retain the flight log and copies of messages in accordance with AR 25-400-2.
- Advise the S3 on all factors affecting mission capabilities, such as personnel, maintenance, and logistics.
- Review, consolidate, and prepare technical, personnel, and administrative reports covering met section and station activities.
- Organize and supervise the met section training program.
- Supervise operator maintenance of met, communications, and vehicular equipment.
- Supervise preparation and distribution of all met messages.
- Ensure adherence to safety procedures during balloon inflation and launching.
- Manage met section logistics for repair parts and expendable items.
- Assign personnel to met teams.
- Instruct and lead crew members in met procedures.

6-17. FA MET SECTION SERGEANT (SSG, MOS 93F30)

The FA met section sergeant will--

- Provide leadership and technical guidance to subordinate personnel.
- Serve as off-shift senior sergeant during periods of extended operation.
- Check data and records.
- Examine data samples for quality control.
- Inspect grounding equipment.
- Decode wind messages.

6-18. FA MET EQUIPMENT REPAIRER (SGT, MOS 93F20H1)

The FA met equipment repairer sergeant will--

- Supervise the second shift during 24-hour operations.
- Perform unit maintenance on the section met equipment.
- Ensure communications are maintained with all users.

- Perform administrative duties as required.

6-19. FA MET EQUIPMENT REPAIRER (SPC, MOS 93F10H1)

The FA met equipment repairer specialist will--

- Operate met equipment on his assigned shift.
- Perform unit maintenance on the section met equipment.
- Operate organic communications equipment.
- Drive the vehicle.

6-20. FA MET CREW MEMBER (SPC, MOS 93F10)

The FA met crew member specialist will--

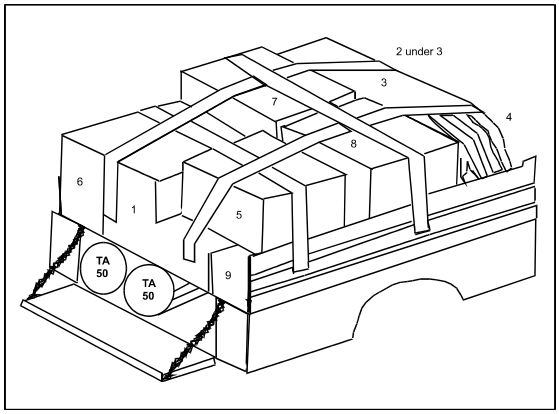
- Operate met equipment on his assigned shift.
- Prepare the balloon train.
- Drive the vehicle.

6-21. FA MET CREW MEMBER (PFC, MOS 93F10)

The FA met crew member private will--

- Operate met equipment on his assigned shift.
- Help prepare the balloon train.
- Drive the vehicle.

Section IV
Suggested Load Plans

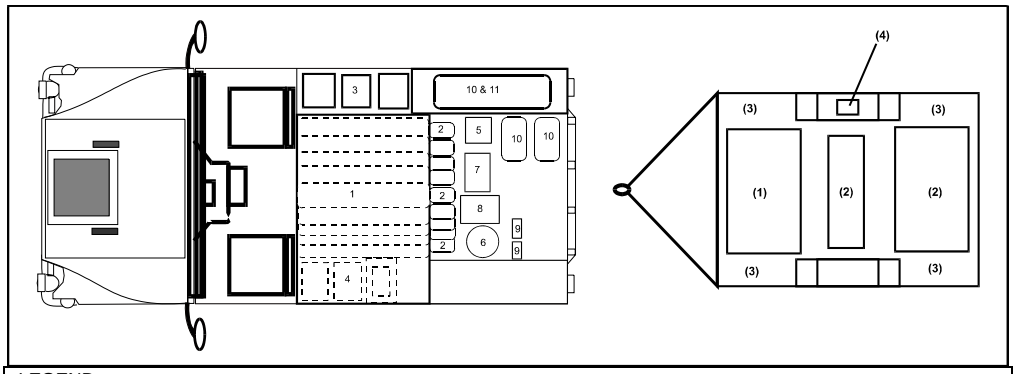


NOTE: This loading plan requires a piece of plywood (6' X 4' X 3/4") under box 1 resting on top of the wheel wells.

LEGEND:
Vehicle

1. Reflector and Alignment Group
2. Elevation Unit
3. Azimuth Unit
4. Tripod (less bag)
5. System Processor
6. NAVAID Antenna
7. Power Supply Unit and Cables
8. RDF Power Supply and Cables
9. Fabricated Case (Radiosondes)

Figure 6-3. Vehicle One (HMMWV Side View)

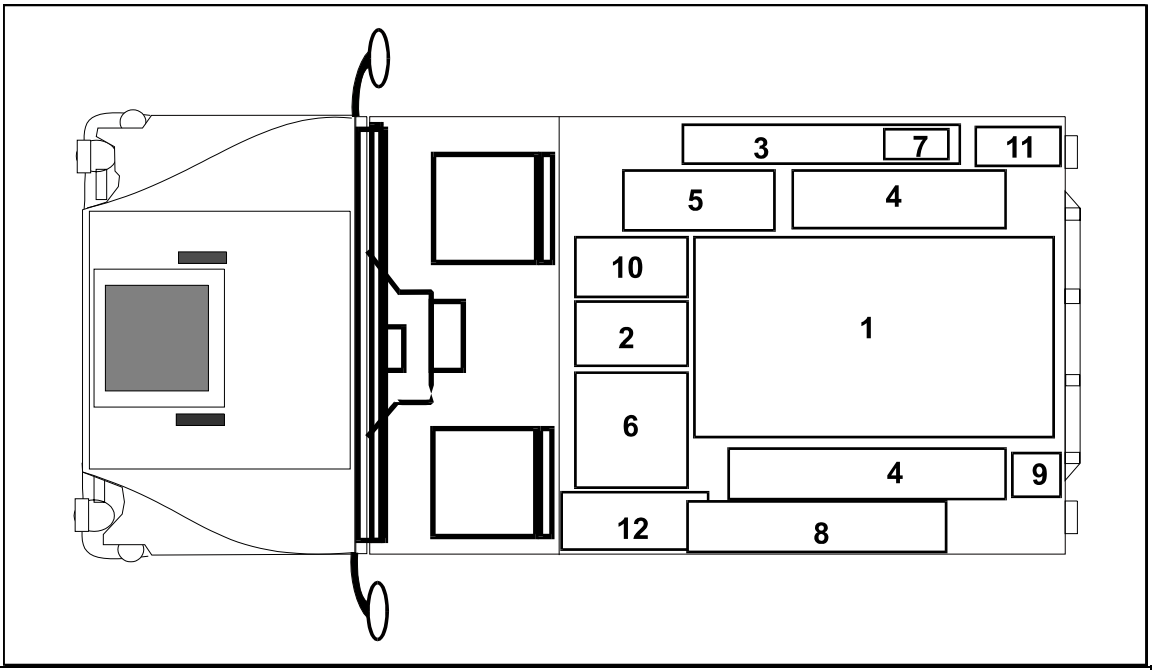


LEGEND:

Vehicle
1. Inflation Launching Device (on top of bottled gas)
2. Helium/Hydrogen Bottled Gas (12 to 16 bottles)
3. Balloons
4. Parachutes and Launching Reels
5. Volume Meter
6. Garbage Can with the following inside
(twine, shroud, grounding straps, volume regulator, light sticks)
7. Camouflage Nets
8. Camouflage Poles
9. Rucksacks
10. B Bags
11. Grounding Rods

Trailer
1. Generator
2. Tool Box
3. Fuel Can Holders
4. Fire Extinguisher

Figure 6-4. Vehicle Two with Trailer



LEGEND

1. 250-Gal Water Drum Collapsible
2. Hydrogen Generator Set
7. Lantern
8. Cots

3. Stove	9. Psychrometer
4. Crew TA-50	10. Barometer
5. Radiosondes	11. Anemometer
6. Calcium Hydride	12. Tents

Figure 6-5. Vehicle Three

Chapter 6
Meteorological Measuring Set, AN/TMQ-38

This chapter discusses the components, site considerations, and personnel of the AN/TMQ-38 section.

Section I
MMS AN/TMQ-38 Equipment

The AN/TMQ-38 is an automated meteorological data processing system. It consists of two main groups, the main equipment group and the RDF equipment group. This section discusses the AN/TMQ-38 and additional equipment. Figure 6-1 shows the AN/TMQ-38 equipment.

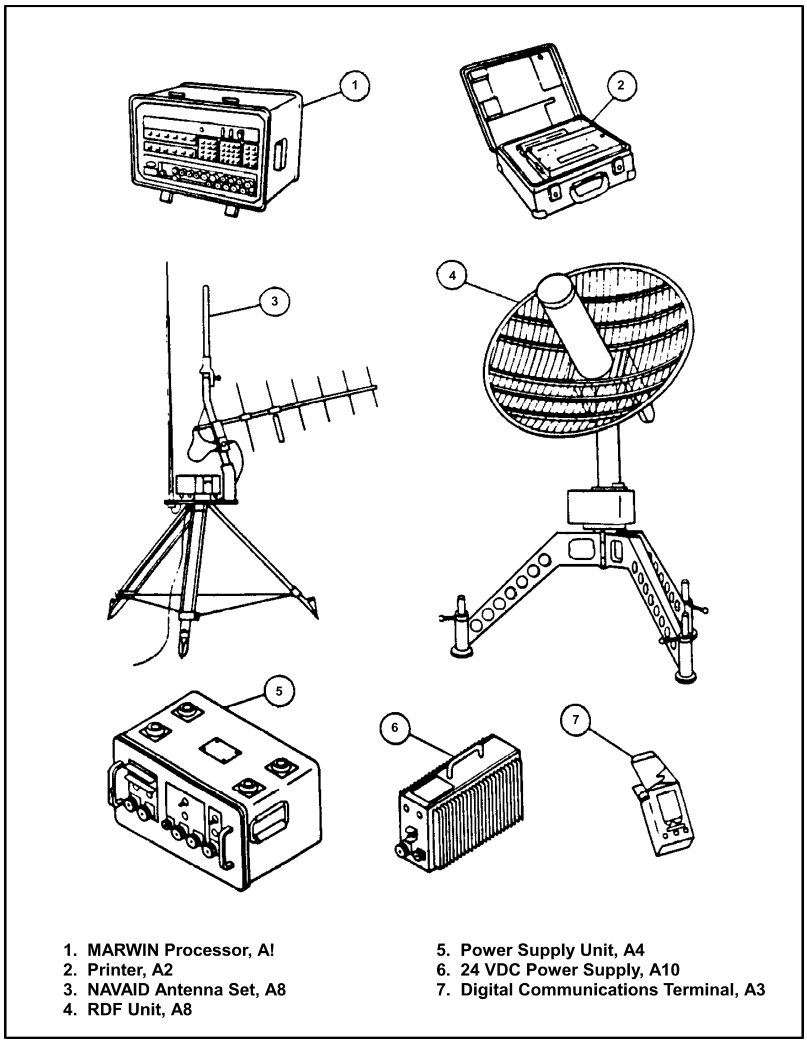


Figure 6-1. AN/TMQ-38 Equipment

6-1. MAIN EQUIPMENT GROUP

NOTE: The AN/TMQ-38 is not housed in a permanent shelter. Met sections must position

the main system group in a temporary shelter, tent, or in the back of a cargo vehicle during operation.

The main equipment group contains the equipment necessary to receive and process met data transmitted by a radiosonde. The main equipment group consists of the systems described below.

a. **NAVAID Antenna System.** When the AN/TMQ-38 operates in the NAVAID mode, the NAVAID antennas receive signals from one of the following NAVAIDS:

- LORAN.
- Omega.
- VLF.

b. **Receiving System**. The receiving system converts, amplifies, and reproduces signals from the NAVAID and RDF antennas and passes this data to the MARWIN processor.

c. **MARWIN Processor**. The MARWIN receives and processes met data and position information. It formats the data into met messages for transmission to using units.

d. **Communication System**. This system receives met messages from the MARWIN, encodes or encrypts, and transmits to subscribers. It also receives and acknow-ledges digital messages.

e. **Page Printer**. The printer provides a hard copy record of all met messages.

f. **Power Supply System**. The AN/TMQ-38 operates from either 120 v AC or +28 v DC primary input power. The power supply unit and the 24 v DC power supply convert the supplied power to the correct voltage for operating the equipment. The RDF operates only when AC power is used.

6-2. RDF EQUIPMENT GROUP

The RDF is a tripod-mounted antenna system that automatically tracks the radiosonde in the atmosphere. It receives met data from the radiosonde and detects position information used for wind computation. The RDF passes the met and position data to the main system group for processing and dissemination. A hand-held Control Display Unit (CDU), con-nected to the antenna by cable, allows for manual control of both the positioning system and the receiver tuning circuit.

6-3. POWER CABLE EQUIPMENT

The power cable equipment provides operating power to the system. It consists of two 50-foot cables to connect an AC power source to the power supply unit. A third ca-ble provides for connecting the power supply unit to a DC power source. These cables are stored in the power supply unit case.

6-4. ASSOCIATED EQUIPMENT

NOTE: The AN/TMQ-38 does not use digital radiosondes.

a. **Radiosonde**. The radiosonde is a small electronic instrument. A free-flight balloon carries it aloft. The radiosonde transmits pertinent weather data from aloft to the met section. The radiosonde senses pressure, temperature, and relative humidity. The AN/TMQ-38 uses different types of radio-sondes depending on the operating mode selected for the planned sounding.

b. **Power Equipment**. The AN/TMQ-38 can operate from vehicle power or an external source. When operating in the RDF mode, an external source of AC power is required. A trailer-mounted power plant is towed by one of the section's vehicles to provide that power.

6-5. COMMUNICATIONS EQUIPMENT

a. **Radios**. The met section is authorized SINCGARS. They are used to communicate with met users and for command and control purposes.

b. **Digital Communication Terminal**. The Digital Communication Terminal (DCT) is a two-way interface device used for receiving and routing digital communications between the met section and remote users.

c. **Digital Nonsecure Voice Terminal**. This telephone, with associated wire connections, is a MSE that allows for voice and digital communications. The DNVT provides access to the common user area communications network.

6-6. VEHICULAR EQUIPMENT

Each section is authorized three HMMWVs. The three vehicles are essentially the same; however, one has been modified by adding a winch. Vehicle one transports the system equipment. Vehicle two carries inflation and launching equipment along with additional supplies. Vehicle three carries supplementary equipment and tows the trailer containing the power plant. Section IV provides example load plans.

6-7. MET STATION MANUAL, AN/TMQ-4B

The met station manual, AN/TMQ-4B, consists of the following:

- Surface observation equipment.
- Balloon inflation equipment.
- Miscellaneous minor components to support the operation of the AN/TMQ-38.

Section II
AN/TMQ-38 Section Site Operations

6-8. SITE SELECTION

Met sections are positioned by the S-3 and met station leader to provide the best possible area of coverage and most valid met data. Section deployment depends largely on the location of firing units, targets, terrain, and weather. When selecting a site, the met station leader must weigh the following considerations:

- Safety.
- Tactical situation.
- Weather forecast and prevailing winds.
- Availability of NAVAID signals.
- Security.
- Communications modes and nets.
- Operating frequencies.
- Electronic warfare activities.
- Areas of coverage.
- Terrain.
- Availability of adequate supply of water.
- Logistical support.
- Unit attachment.

6-9. SURVEY REQUIREMENTS

This paragraph implements QSTAG 1166.

The met station leader conducts a ground reconnaissance to determine the exact positions for major items or groups of equipment. Once this is done, he selects two reference points to

facilitate orienting the RDF to true north when it is emplaced. Reference points should be fixed, easily identified objects, such as a tall pole or the fork of a large tree.

a. **Survey Available**. The met station leader emplaces the section to fifth-order accuracy or with the GPS. The survey section will provide the met section with the latitude, longitude, and height of the met section.

b. **Survey Not Available**. If survey support is not available, the met station leader determines station altitude and location from an area map. The map datum is World Geodetic System 84.

6-10. RDF GROUP EMPLACEMENT

NOTE: If the soundings are to be performed in the NAVAID mode, the RDF is not assembled.

The RDF cannot be emplaced more than 100 feet from the processing equipment site due to the cable length. The RDF should be placed on reasonably level terrain. It should not be screened by large obstacles that may interfere with signal reception. The position selected for the RDF should have a clear area downwind to observe balloon release. There must be no tall objects to obstruct line of sight from the RDF to a radiosonde in flight.

6-11. MAIN EQUIPMENT GROUP EMPLACEMENT

The met station leader positions the main equipment, MARWIN processor, power supply unit, printer, and the DCT in an improvised shelter on firm level ground. The position cannot be more than 100 feet from the RDF or power equipment. The NAVAID antennas should be positioned as described above for the RDF.

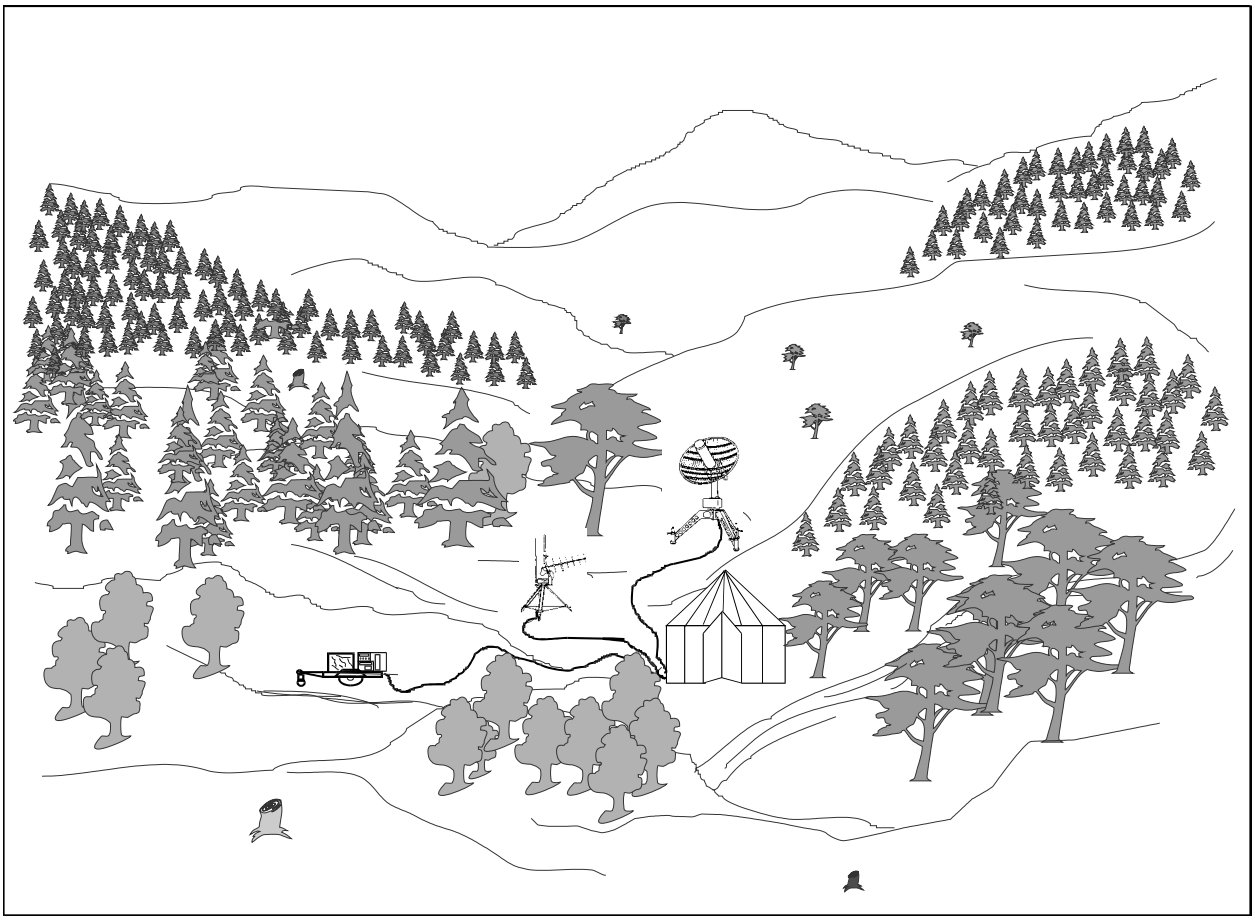
6-12. POWER EQUIPMENT EMPLACEMENT

Power equipment must be placed within 100 feet of the main equipment group due to cable length. Ideally, the power equipment should be placed downwind to reduce noise at the operation site. Once the power equipment trailer is disconnected from the vehicle that tows it, the vehicle is moved into a concealed area.

6-13. BALLOON INFLATION SITE LOCATION

NOTE: If the section uses hydrogen gas for inflation, special safety and environmental protection measures are required. See Appendix H for more information.

Upon entering the AO, the vehicle transporting the balloon inflation and launching equipment moves to the inflation site. The necessary equipment is unloaded, and the vehicle is moved into a concealed area. The inflation site should be downwind of the operation site and RDF positions whenever possible. Figure 6-2 provides an example of a site occupation.



NOTE: Since the maximum cable length is 100 feet (30 meters) the distance between the operation site and its interfacing equipment cannot exceed this distance:

- Operation site to RDF, 100 feet (30 meters) maximum.
- Operation site to generator, 100 feet (30 meters) maximum.
- Operation site to NAVAID antenna set 100 feet (30 meters) maximum.

Figure 6-2. Site Occupation

6-14. CAMOUFLAGE

The modules of radar-scattering camouflage in Table 6-1 are required for camouflaging the system. Camouflage procedures are outlined in TM 5-1080-200-13&P.

EQUIPMENT	MODULES
1 1/4-ton truck (3 each)	6
1/4-ton trailer w/generator (1 each)	2
RDF	1
NAVAID antenna set	1
Tent	2

Table 6-1. Radar Scattering Camouflage Modules

6-15. DISPLACEMENT PROCEDURES

Commanders move met sections as needed to maintain met support. Therefore, crew members must be trained for mobility and must be able to rapidly displace, move, and occupy a new site during critical periods of the battle. The met station leader informs the S3 when the validity of the last message from the current position will expire and how much time is required to march-order the section. He recommends the best time to make the displacement and recommends a course of action to relay met data from adjacent sections while displacing. The met station leader's briefing to section personnel before each displacement should include, as applicable, the following:

- Broadcast time of the last met message from the current position.
- Broadcast time of the first met message from the next position.
- Procedures for monitoring, copying, and transmitting met data from adjacent met sections on both the left and right flanks. Supported units will choose the message from their nearest met section.
- Section march-order sequence and when the camouflage systems will be dropped, packed, and loaded.
- Departure time and/or whether the section has road clearance to move independently.
- Where the met vehicles will be positioned in the battery column.
- Route of march and any significant landmarks.
- Designation of the section representative on the reconnaissance party.

Section III
AN/TMQ-38 Section Personnel

TITLE	MOS	RANK	
Met station leader	93F40	SFC	1
FA met section sergeant	93F30	SSG	1
FA met equipment repairer	93F20H1	SGT	1
FA met equipment repairer	93F10H1	SPC	1
FA met crew member	93F10	SPC	1
FA met crew member	93F10	PFC	1
		TOTAL	6

LEGEND:
SFC = SERGEANT FIRST CLASS SPC = SPECIALIST
SSG = STAFF SERGEANT PFC = PRIVATE FIRST CLASS
SGT = SERGEANT

Table 6-2. AN/TMQ-38 Section Personnel

6-16. MET STATION LEADER (SFC, MOS 93F40)

The met station leader will--

- Help the S3 prepare the met plan.
- Advise the S3 on the employment and operation of met assets within the AO.
- Supervise met section operations.
- Coordinate with the S4 for logistical support.
- Coordinate with the signal staff officer to prioritize means of communication and dissemination of messages.
- Perform site selection and location.
- Direct the operation, emplacement, and displacement of the met section.
- Maintain quality control of met data. Submit necessary reports, and maintain a flight log showing the following:
  - Dates.
  - Location.
  - Flight number.
  - Expendables consumed.
  - Other pertinent information.
- Retain the flight log and copies of messages in accordance with AR 25-400-2.
- Advise the S3 on all factors affecting mission capabilities, such as personnel, maintenance, and logistics.
- Review, consolidate, and prepare technical, personnel, and administrative reports covering met section and station activities.
- Organize and supervise the met section training program.
- Supervise operator maintenance of met, communications, and vehicular equipment.
- Supervise preparation and distribution of all met messages.
- Ensure adherence to safety procedures during balloon inflation and launching.
- Manage met section logistics for repair parts and expendable items.
- Assign personnel to met teams.
- Instruct and lead crew members in met procedures.

6-17. FA MET SECTION SERGEANT (SSG, MOS 93F30)

The FA met section sergeant will--

- Provide leadership and technical guidance to subordinate personnel.
- Serve as off-shift senior sergeant during periods of extended operation.
- Check data and records.
- Examine data samples for quality control.
- Inspect grounding equipment.
- Decode wind messages.

6-18. FA MET EQUIPMENT REPAIRER (SGT, MOS 93F20H1)

The FA met equipment repairer sergeant will--

- Supervise the second shift during 24-hour operations.
- Perform unit maintenance on the section met equipment.
- Ensure communications are maintained with all users.

- Perform administrative duties as required.

6-19. FA MET EQUIPMENT REPAIRER (SPC, MOS 93F10H1)

The FA met equipment repairer specialist will--

- Operate met equipment on his assigned shift.
- Perform unit maintenance on the section met equipment.
- Operate organic communications equipment.
- Drive the vehicle.

6-20. FA MET CREW MEMBER (SPC, MOS 93F10)

The FA met crew member specialist will--

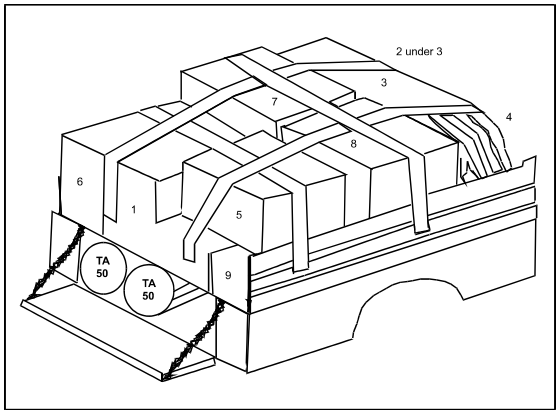
- Operate met equipment on his assigned shift.
- Prepare the balloon train.
- Drive the vehicle.

6-21. FA MET CREW MEMBER (PFC, MOS 93F10)

The FA met crew member private will--

- Operate met equipment on his assigned shift.
- Help prepare the balloon train.
- Drive the vehicle.

Section IV
Suggested Load Plans

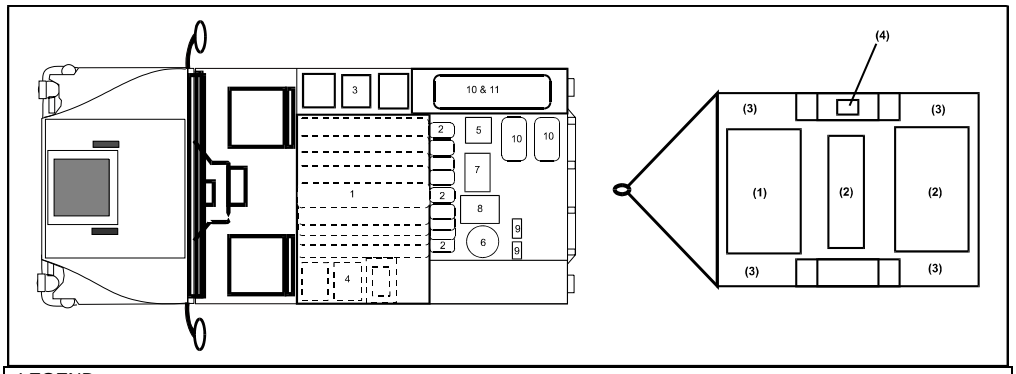


NOTE: This loading plan requires a piece of plywood (6' X 4' X 3/4") under box 1 resting on top of the wheel wells.

LEGEND:
Vehicle

1. Reflector and Alignment Group
2. Elevation Unit
3. Azimuth Unit
4. Tripod (less bag)
5. System Processor
6. NAVAID Antenna
7. Power Supply Unit and Cables
8. RDF Power Supply and Cables
9. Fabricated Case (Radiosondes)

Figure 6-3. Vehicle One (HMMWV Side View)

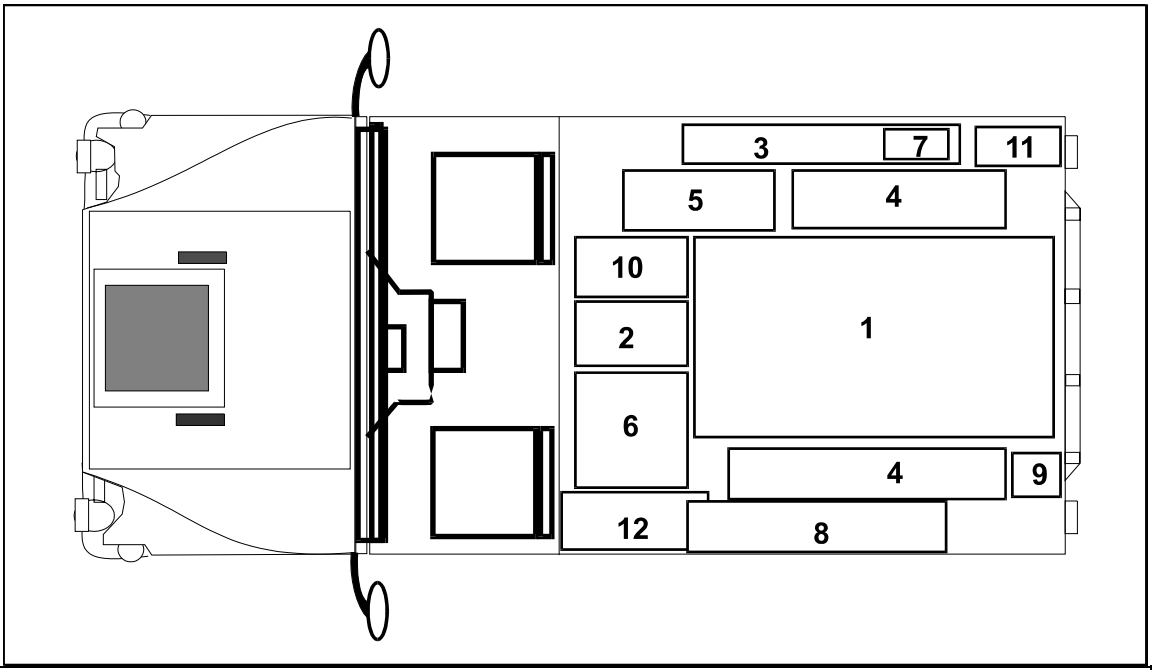


LEGEND:

Vehicle
1. Inflation Launching Device (on top of bottled gas)
2. Helium/Hydrogen Bottled Gas (12 to 16 bottles)
3. Balloons
4. Parachutes and Launching Reels
5. Volume Meter
6. Garbage Can with the following inside
(twine, shroud, grounding straps, volume regulator, light sticks)
7. Camouflage Nets
8. Camouflage Poles
9. Rucksacks
10. B Bags
11. Grounding Rods

Trailer
1. Generator
2. Tool Box
3. Fuel Can Holders
4. Fire Extinguisher

Figure 6-4. Vehicle Two with Trailer



LEGEND

1. 250-Gal Water Drum Collapsible
2. Hydrogen Generator Set
7. Lantern
8. Cots

3. Stove	9. Psychrometer
4. Crew TA-50	10. Barometer
5. Radiosondes	11. Anemometer
6. Calcium Hydride	12. Tents

Figure 6-5. Vehicle Three

Chapter 7
Meteorological Measuring Set, AN/TMQ-41

This chapter discusses the components, site considerations, and personnel of the AN/TMQ-41 equipped section.

Section I
MMS AN/TMQ-41 Equipment

The AN/TMQ-41 is an automated meteorological data processing system. It consists of two main equipment groups, the shelter group and the RDF group. This section discusses the AN/TMQ-41 and additional equipment. Figure 7-1 shows the AN/TMQ-41 equipment.

The shelter equipment group contains the equipment needed to receive and process met data transmitted by a radiosonde. The shelter equipment group consists of the systems described below.

7-1. SHELTER EQUIPMENT GROUP

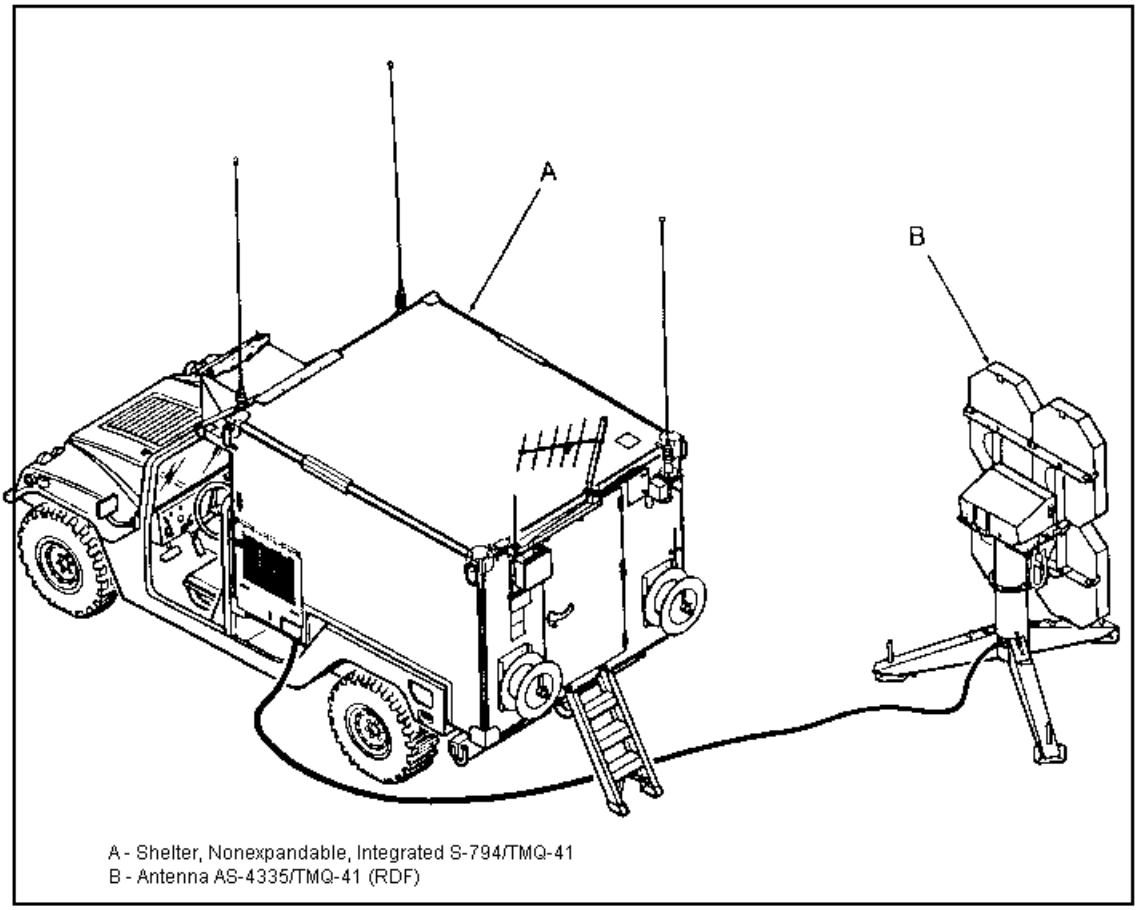


Figure 7-1. AN/TMQ-41 Equipment

a. **NAVAID Antenna System**. When the AN/TMQ-41 operates in the NAVAID mode, the NAVAID antennas receive signals from one of the following NAVAIDS:

- LORAN.
- Omega.
- VLF.

b. **Receiving System**. This system amplifies and converts signals received by the NAVAID and RDF antennas and passes them to the MARWIN processor.

c. **MARWIN Processor**. The MARWIN receives and processes met data and position information. It formats the data into met messages for transmission to using units.

d. **Communications System**. This system receives met messages from the MARWIN, encodes or encrypts, and transmits to subscribers. The system also receives and acknowledges digital messages.

e. **Page Printer**. The printer provides a hard copy record of all met messages.

f. **Power Supply System**. The AN/TMQ-41 operates from a 230 v AC or +28 v DC primary input. A power entry assembly and power control unit convert the supplied power to the correct voltage for operating the equipment. The RDF and air conditioners can be operated only when AC power is used.

7-2. RDF EQUIPMENT GROUP

The RDF is a tripod-mounted antenna system that automatically tracks the radiosonde in the atmosphere. It receives met data and detects position information used for wind computation. The RDF passes this data to the shelter equipment for processing and dissemination. A hand terminal connected to the antenna by cable allows for manual control of the positioning system as well as the receiver tuning circuit.

7-3. GENERATOR CABLE EQUIPMENT

The cable equipment provides primary AC power to the system. It consists of two 50-foot cables and a pigtail cable to connect the generator or commercial power source to the power entry assembly at the shelter. A cable reel is provided for storing these cables on the back of the equipment shelter.

7-4. ASSOCIATED EQUIPMENT

a. **Radiosonde**. The radiosonde is a small electronic instrument carried aloft by a free-flight balloon. The aloft radiosonde senses and transmits pressure, temperature, and relative humidity to the met section. The AN/TMQ-41 uses different types of radiosondes, depending on the operating mode selected for the planned sounding.

b. **Power Equipment**. The AN/TMQ-41 operates either from vehicle power or an external power source. When performing mobile operations, power is supplied by the vehicle on which it is mounted. When the air conditioners are on or when operating the RDF an external source of power is required. A trailer-mounted power plant is towed by one of the sections vehicles to provide power.

7-5. COMMUNICATIONS EQUIPMENT

a. **Radios**. The met section is authorized SINCGARS. They are used for communications with met users and command and control.

b. **Digital Computer System, Lightweight Computer Unit**. This two-way interface device is used for routing digital communications between the met section and remote users.

c. **Digital Nonsecure Voice Terminal**. This telephone, with associated wire connections, is a MSE device that allows for voice and digital communications. The DNVT provides access to the common user area communications network.

7-6. VEHICULAR EQUIPMENT

Each section is authorized three HMMWV and three trailers. The three vehicles are the heavy-variant HMMWV, and each is equipped with a

200-amp kit. Vehicle one transports the operations shelter and tows the power generator. Vehicle two transports supplemental equipment and tows the trailer containing the balloon inflation equipment and expendable supplies. Vehicle three for the AN/TMQ-42 hydrogen generator equipped section is only capable of transporting the hydrogen generator. The trailer towed by the vehicle transports the methanol. For sections equipped with the AN/TMQ-3 hydrogen generator, vehicle three transports supplementary equipment and the trailer carries the water bladders. Section IV provides example load plans.

Section II
AN/TMQ-41 Section Site Operations

7-7. SITE SELECTION

Met sections are positioned by the S-3 and met station leader to provide the best possible area of coverage and most valid met data. Section deployment depends largely on the location of firing units, targets, terrain, and weather. When selecting a site, the met section leader must weigh the following considerations:

- Safety.
- Tactical situation.
- Weather forecast and prevailing winds.
- Availability of NAVAID signals.
- Security.
- Communications modes and nets.
- Operating frequencies.
- Electronic warfare activities.
- Areas of coverage.
- Terrain.
- Availability of adequate supply of water.
- Logistical support.
- Unit attachment.

7-8. SURVEY REQUIREMENTS

This paragraph implements QSTAG 1166.

The met station leader conducts a ground reconnaissance to determine the exact positions for major items of equipment. Once this is done, he selects two reference points to facilitate orienting the RDF to true north. Reference points should be fixed, easily identified objects, such as a tall pole or the fork of a large tree.

a. **Survey Available**. The met station leader emplaces the system to fifth-order accuracy or with the GPS. The survey section will provide the met section with the latitude, longitude, and height of the met section.

b. **Survey Not Available**. If survey support is not available, the met station leader determines station altitude and location from an area map. The map datum is World Geodetic System 84.

7-9. RDF EMPLACEMENT

NOTE: If the soundings are to performed in the NAVAID mode, the RDF is not emplaced.

The RDF cannot be emplaced more than 100 feet from the equipment shelter due to cable length. The RDF should be placed on reasonably level terrain. It should not be screened by large obstacles that may interfere with signal reception. The position selected for the RDF should have a clear area downwind to observe balloon release. There must be no tall objects to obstruct line of sight from the RDF to a radiosonde in flight.

7-10. EQUIPMENT SHELTER EMPLACEMENT

The met station leader positions the shelter on firm level ground. The shelter cannot be positioned more than 100 feet from the RDF or power equipment due to cable length. It should not be positioned under power lines.

7-11. POWER EQUIPMENT EMPLACEMENT

The power plant provides the hydrogen generator and the shelter with power. It can be no more than 100 feet from either piece of equipment. Safety requirements prohibit positioning the power equipment within 50 feet of the hydrogen generator or the methanol storage area. Once the power equipment trailer is disconnected from the vehicle that tows it, the vehicle moves to a concealed area.

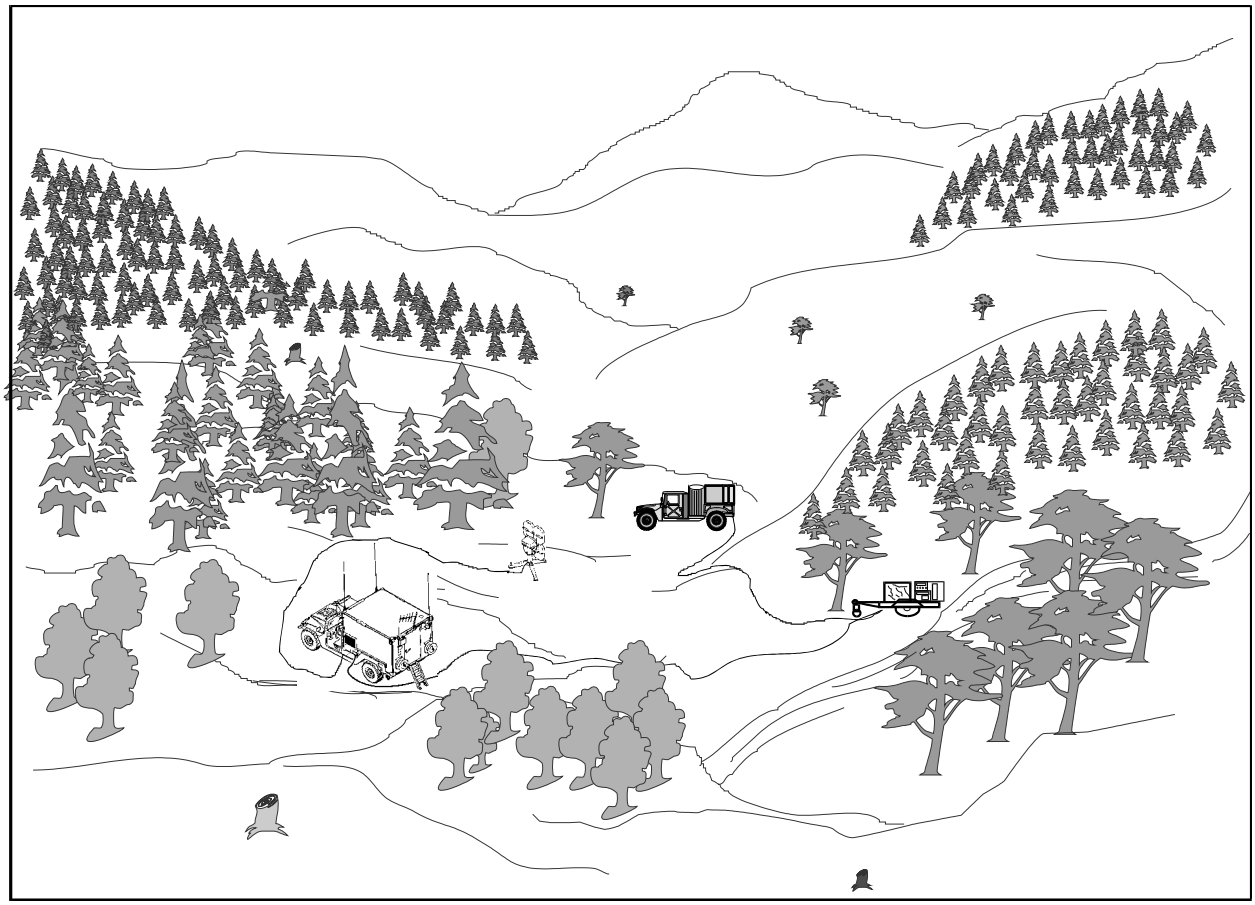
7-12. BALLOON INFLATION SITE

NOTE: If the section uses hydrogen gas for inflation, special safety measures are required. See Appendix H for more information.

Upon entering the area of operation, the vehicle transporting the balloon inflation and launching equipment moves to the inflation site. The necessary equipment is unloaded, and the vehicle moves to a concealed area. The inflation site should be downwind of the equipment shelter and RDF if possible.

a. **Methanol Storage Trailer**. The trailer is positioned in the inflation area. It should be upwind and no closer than 50 feet from any spark producing equipment. The area must be designed to contain all spills. Methanol must not be exposed to direct sun light. No smoking signs must be placed on all sides of the area. The trailer and the containers must be properly grounded.

b. **Meteorological Hydrogen Generator**. After disconnecting the methanol trailer, the vehicle with the meteorological hydrogen generator (MHG) moves into position. It cannot be closer than 50 feet from any spark producing equipment. It must be within 100 feet of the power plant due to the length of cable. Figure 7-2 provides an example of a site occupation.



NOTE: Because the maximum cable length is 100 feet (30 meters), the distance between the shelter and its interfacing equipment cannot exceed the following:

- Shelter to RDF antenna (one cable W103) - 100 feet (30 meters) maximum.
- Shelter to generator trailer (two cables W101 and one cable W105) - 100 feet (30 meters) maximum.
- Shelter to remote NAVAID antennas (one cable W111, one cable W112) - 100 feet (30 meters) maximum.
- Hydrogen generator to power generator (two cables W104 and one cable W103) - 100 feet (30 meters) maximum.

Figure 7-2. Site Occupation

7-13. CAMOUFLAGE

The modules of radar-scattering camouflage in Table 7-1 are required for camouflaging the system. Camouflage procedures are outlined in TM 5-1080-200-13&P.

EQUIPMENT	MODULES
1 1/4-ton truck with shelter	2
1 1/4-ton truck (transports MHG if issued)*	3
1 1/4-ton truck	2
1 1/4-ton trailer (3 each)	3
RDF	1
NAVAID anteena set	1
Tent	2
*Ensure the generator chimney is not covered with camouflage when generator is operating.	

Table 7-1. Radar Scattering Camouflage Modules

7-14. DISPLACEMENT PROCEDURES

Commanders move met sections as needed to maintain met support. Therefore, crew members must be trained and able to displace, move, and occupy a new site rapidly during critical periods of the battle. The met station leader informs the S3 when the validity of the last message from the current position will expire and how much time is required to march-order the section. He recommends the best time to make the displacement and a course of action to relay met data from adjacent sections while the section is displacing. The met station leader's briefing of section personnel before each displacement should include, as applicable, the following:

- Broadcast time of the last met message from the current position.

- Broadcast time of the first met message from the next position.

- Procedures for monitoring, copying, and transmitting met data from adjacent met sections on both the left and right flanks.

- Section march-order sequence and when the camouflage systems will be dropped, packed, and loaded.

- Departure time and/or whether the section has road clearance to move independently.

- Where the met vehicles will be positioned in the battery column.

- Route of march and any significant landmarks.

- Designation of the section representative on the reconnaissance party.

Section III
AN/TMQ-41 Section Personnel

US ARMY			
TITLE	MOS	RANK	
Met station leader	93F40	SFC	1
FA met section sergeant	93F30	SSG	1
FA met equipment repairer	93F20H1	SGT	1
FA met equipment repairer	93F10H1	SPC	1
FA met crew member	93F10	SPC	1
FA met crew member	93F10	PFC	1
		TOTAL	6

LEGEND:
SFC = SERGEANT FIRST CLASS
SSG = STAFF SERGEANT
SGT = SERGEANT
SPC = SPECIALIST
PFC = PRIVATE FIRST CLASS

US MARINE CORPS			
TITLE	MOS	RANK	
Team chief	0848	SSGT	1
Arty met man	0847	SGT	1
Arty met man	0847	CPL	1
Arty met man/driver	0847	LCPL	1
Arty met man/driver	0847	PFC	2
		TOTAL	6

LEGEND:
SSGT = STAFF SERGEANT
SGT = SERGEANT
CPL = CORPORAL
LCPL = LANCE CORPORAL
PFC = PRIVATE FIRST CLASS

Table 7-2. AN/TMQ-41 Section Personnel (US Army) and AN/TMQ-41 Section Personnel (US Marine Corps)

NOTE: Duties are the same for both Army and Marine Corps personnel.

7-15. MET STATION LEADER (SFC, MOS 93F40)

The met station leader will--

- Help the S3 prepare the met plan.
- Advise the S3 on the employment and operation of the met assets within the division area.
- Supervise met section operations.
- Coordinate with the S4 for logistical support.
- Coordinate with the signal staff officer to prioritize means of communication and dissemination of messages.
- Perform sire selection and location.
- Direct the operation, emplacement, and displacement of the met section.
- Maintain quality control of met data. Submit necessary reports, and maintain a flight log showing the following:
  - Dates.

- Location.
- Flight number.
- Expendables consumed.
- Other pertinent information.

- Retain the flight log and copies of messages in accordance with AR 25-400-2.

- Advise the S3 on all factors affecting mission capabilities, such as personnel, maintenance, and logistics.

- Review, consolidate, and prepare technical, personnel, and administrative reports covering met section and station activities.

- Organize and supervise the met section training program.

- Supervise operator maintenance of met, communications, and vehicular equipment.

- Supervise preparation and distribution of all met messages.

- Ensure adherence to safety procedures during inflation.

- Manage met section logistics for repair parts and expendable items.

- Assign personnel to met teams.

- Instruct and lead crew members in met procedures.

7-16. FA MET SECTION SERGEANT (SSG, MOS 93F30)

The FA met section sergeant will--

- Provide leadership and technical guidance to subordinate personnel.

- Serve as off-shift senior sergeant during periods of extended operation.

- Check data and records.

- Examine data samples for quality control.

- Inspect grounding equipment.

- Decode wind messages.

7-17. FA MET EQUIPMENT REPAIRER (SGT, MOS 93F20H1)

The FA met equipment repairer sergeant will--

- Supervise the second shift during 24-hour operations.

- Perform unit maintenance on section met equipment.

- Ensure communications are maintained with all users.

- Perform administrative duties as required.

7-18. FA MET EQUIPMENT REPAIRER (SPC, MOS 93F10H1)

The FA met equipment repairer specialist will--

- Operate met equipment on his assigned shift.

- Perform unit maintenance on section met equipment.

- Operate organic communications equipment.

- Drive the vehicle.

7-19. FA MET CREW MEMBER (SPC, MOS 93F10)

The FA met crew member specialist will--

- Operate met equipment on his assigned shift.

- Help prepare the balloon train.

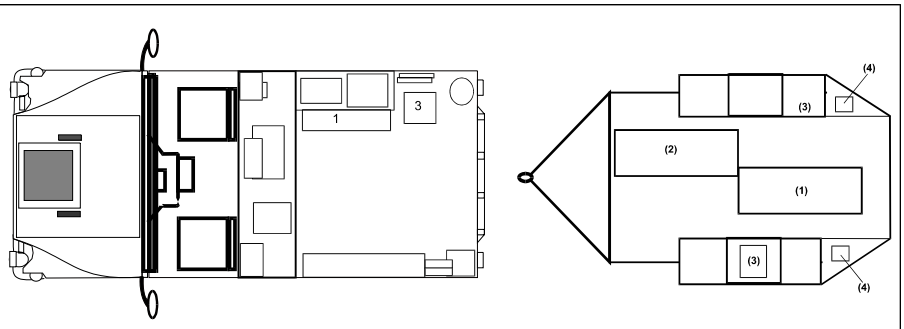
- Drive the vehicle.

7-20. FA MET CREW MEMBER (PFC, MOS 93F10)

The FA met crew member private will--

- Operate met equipment on his assigned shift.
- Help prepare the balloon train.
- Drive the vehicle.

Section IV
Suggested Load Plans

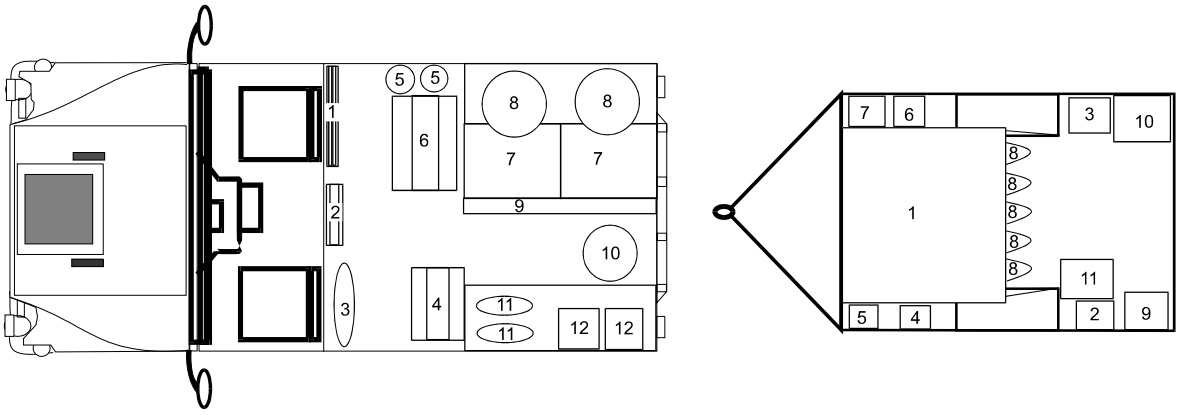


LEGEND:

Vehicle
1. Storage Shelf
   - A. Anemometer
   - B. Aspirator, Psychrometer
   - C. Barometer, Digital
   - D. Compass, Magnetic
   - E. Multimeter
   - F. Tool Kit, TK-33
   - G. Radiosondes
2. Tunnel (storage area under shelter)
   - A. Computer Paper
   - B. Radiosondes
   - C. Reeling Machine RL-39
   - D. Cable Telephone WF-16/U
   - E. Cable Telephone WD-1
3. Tool Box TK-101

Trailer
1. Generator
2. Generator
3. Control Unit
4. Fire Extinguisher

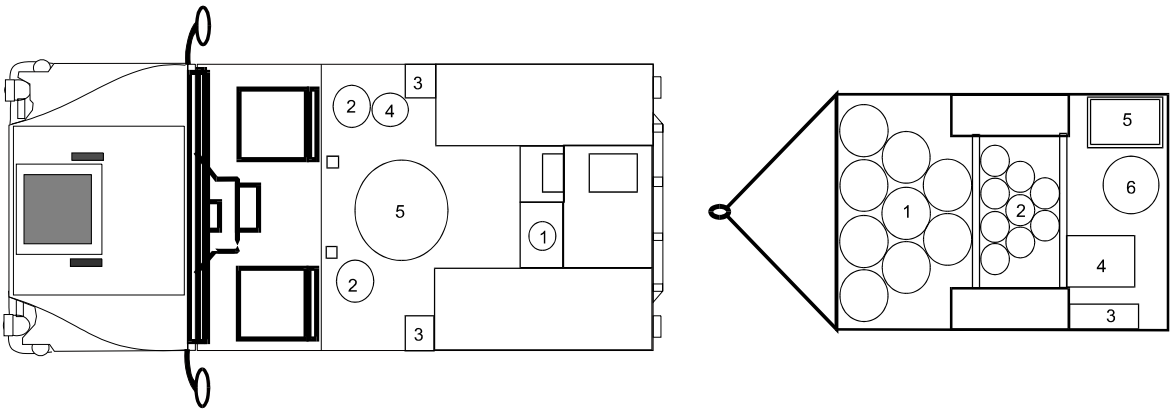
Figure 7-3. Vehicle One with Trailer



LEGEND:

Vehicle	Trailer
1. Field Tables	1. Inflation Launching Device
2. Chairs	2. Balloons, ML-635
3. Cargo Net	3. Balloons, ML-519
4. 5-Gal Water Containers	4. Balloons, ML-537
5. Stove	5. Balloons, ML-159A
6. Cots	6. Balloons, ML-160
7. Tents	7. Balloons, ML-161
8. Camo Nets	8. Helium Bottles
9. Tent Poles	9. Volume Meter
10. 35-Gal Garbage Can	10. Parachutes
11. B-Bags	11. Box, Light Sticks, Wrist Strap, Nozzles, etc.
12. Ruck Sacks	

Figure 7-4. Vehicle Two with Trailer



LEGEND:

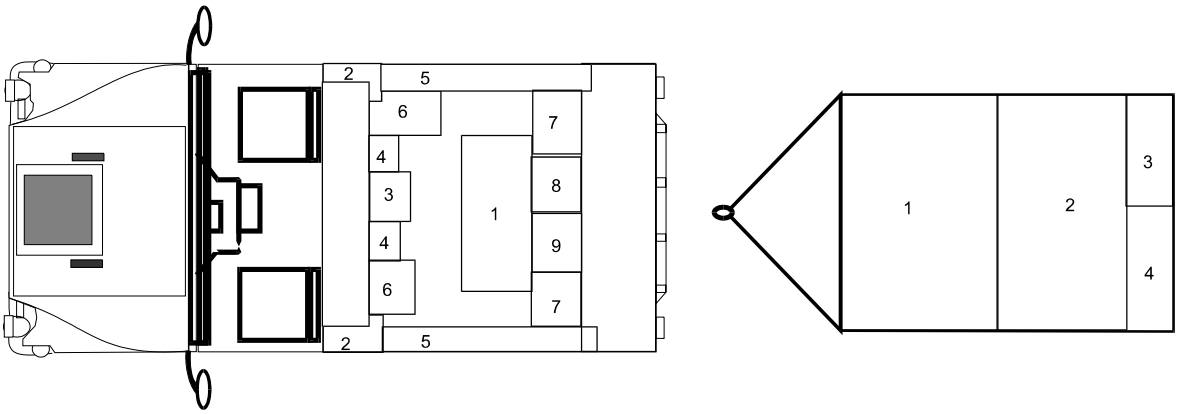
Vehicle

1. Starting Gas (Hydrogen)
2. Helium Gas (Purging)
3. 5-Gallon Jerry Cans (Waste)
4. External Starting Cylinder
5. Hydrogen Storage Tank

Trailer

1. Charge Mix 15-Gallon Drum
2. Methanol 5-Gallon Container
3. Pump Flammable Liquid
4. Box Power Supply 12V Electric Cable 100 ft Starter Gas Hose
5. Spill Containers (Jumbo Tub)
   - 1 Regulator Flammable Gas
   - 3 PR Chemical Proof Gloves
   - 3 Wrist Straps
   - 3 Rubber Apron Chemical
   - 3 Full Face Shield
   - 1 5-Pound Fire Extinguisher
   - 1 Funnel Plastic
   - 1 Splash Pan
   - 1 Eye Wash Kit
   - Absorbent Socks
6. Spill Kit

Figure 7-5. Vehicle Three with Trailer
(AN/TMQ-42 Equipped Section)



LEGEND:

Vehicle

1. Charge Calcium Hydride)
2. Stove
3. Hydrogen Generator Set
4. Tents
5. Cots
6. Lantern
7. Crew TA-50
8. Camouflage Net
9. Camouflage Poles

Trailer

1. 250-gal Water Drum, Collapsible
2. 250-gal Water Drum, Collapsible
3. Camouflage Net
4. Camouflage Poles

Figure 7-6. Vehicle Three with Trailer (AN/TMQ-3 Equipped Section)

Chapter 8
Balloon Inflation and Launching Procedures

This chapter describes the procedures for inflating and launching balloons.

Section I
Overview

WARNING
HYDROGEN GAS, AS WELL AS METHANOL USED WITH THE HYDROGEN GENERATOR, AN/TMQ-42, IS EXTREMELY FLAMMABLE AND SHOULD BE CONSIDERED EXPLOSIVE WHEN CONFINED UNDER PRESSURE IN THE PRESENCE OF AMBIENT AIR. STORAGE, HANDLING, AND DISPOSAL PROCEDURES OF METHANOL MUST BE STRICTLY FOLLOWED. SEE APPENDIX H FOR DETAILED INFORMATION.

8-1. GENERAL

While the met equipment is being emplaced, powered, and initialized, the met station leader dispatches two crew members to the balloon inflation area to prepare a balloon for the sounding. Since balloon inflation is the most time-consuming of all the section tasks, the section should begin this task as soon as possible after it arrives at the site. The met section inflates sounding balloons by using the inflation and launching device or an inflation shelter. The balloons are inflated by compressed gas or gas produced by a hydrogen generator set.

8-2. SAFETY PROCEDURES

In addition to the normal safety measures prescribed for all soldiers, met personnel must be cautious when generating gas or using compressed gas.

a. **Hydrogen Gas.** Hydrogen gas is highly flammable. Since helium is an inert gas, it should be used, when available, to inflate balloons. If hydrogen must be used, the safety precautions below must be carefully followed. Met crew members should--

(1) Display conspicuous warning signs where hydrogen is generated, used, or stored. For example, **DANGER-HYDROGEN - No Smoking Within 50 Feet**. Signs must also be displayed around the methanol storage area.

(2) Never light a match, smoke, or cause a spark near a site where hydrogen is being generated or used. They should remove all possible sources of flame and sparks.

(3) Wear rubber-soled shoes during inflation. They should not wear shoes with exposed nails, which might strike against metal, stones, or concrete floors and produce a spark. Materials such as wool and nylon should not be worn when inflating with hydrogen gas.

(4) Never drop or strike metal tools against anything that might cause a spark.

(5) Remove all metal objects, such as watches and key chains, prior to inflating the balloon.

(6) Never mix hydrogen with air. They should expel all air from the balloon before inflating it with hydrogen.

(7) Never expose the hydrogen cylinder, generator, or methanol to direct sunlight. They should always store hydrogen bottles, calcium hydride, and methanol in the shade.

(8) Remove all constrictions from the balloon neck; keep all hydrogen passages clear.

(9) Use inflation and launching device to minimize balloon handling.

(10) Inflate the balloon slowly on days of low relative humidity when static electricity is easily generated. If the air temperature is above freezing, met crew members should lightly sprinkle the inflation area with water.

(11) Inflate the balloon slowly when using compressed hydrogen or helium in order to avoid bursting or over-inflation. They should use the compressed gas regulator. A crew member adjusts the regulator so that no more than 10 pounds per square inch (PSI) of gas is being released into the balloon.

(12) Never deflate a hydrogen-filled balloon; release it gradually.

WARNING
IF THE HISSING SOUND OF A GAS LEAK FROM THE BALLOON IS HEARD, CLOSE THE CYLINDER VALVE IMMEDIATELY. TWIST THE NECK OF THE BALLOON, REMOVE IT FROM THE INFLATION LAUNCHING DEVICE, AND RELEASE IT.

(13) Wear a metal wristband connected to a flexible wire that leads to a good ground when in an area where inflation is in progress. The band and wire will provide a path to ground for static electricity.

(14) Ground the inflation equipment to provide a path to ground for any static electricity generated in the equipment. They should also use ground cables to interconnect all metal parts of the inflation equipment with ground.

(15) Never remove the hydrogen generator ML-303/TM from the water until the generation of hydrogen gas has stopped. Removing the generator from the water while hydrogen is being generated may cause an explosion. If the balloon is fully inflated before the calcium hydride charges are expended, met crew members should allow the excess gas to escape into the air.

(16) Turn their faces away from charge canisters to prevent eye injuries when punching initial holes. Pressure may exist within the calcium hydride charge canisters.

(17) Follow the two-man rule for safety even though not all procedures require two personnel.

(18) See TMs 11-6660-222-12, 11-2413, and 11-6660-287-13, and Federal Meteorological Handbook (FMH) No. 3 for further information on hydrogen safety precautions. Safety precautions for handling commercial hydrogen are in AR 700-68.

b. **Grounding Procedures.** Whenever hydrogen is used, met crew members must use ground cables to connect all metal parts of the equipment to each other and to a grounding field made of a minimum of two ground rods. On days of low relative humidity, when static electricity is high, use additional grounding rods. Metal surfaces are cleaned with sandpaper to get a good connection. Then ground clamps or alligator clips are used to connect the cables to the metal. A crew member in the immediate area where hydrogen is being generated or used should be individually grounded by using the issued grounding strap assemblies. A path to ground for static electricity is particularly important for the crew member who actually handles the balloon. Detailed grounding techniques are explained in TC 11-6 and FMH No. 3. Also, see Figures 8-1 and 8-2 for examples.

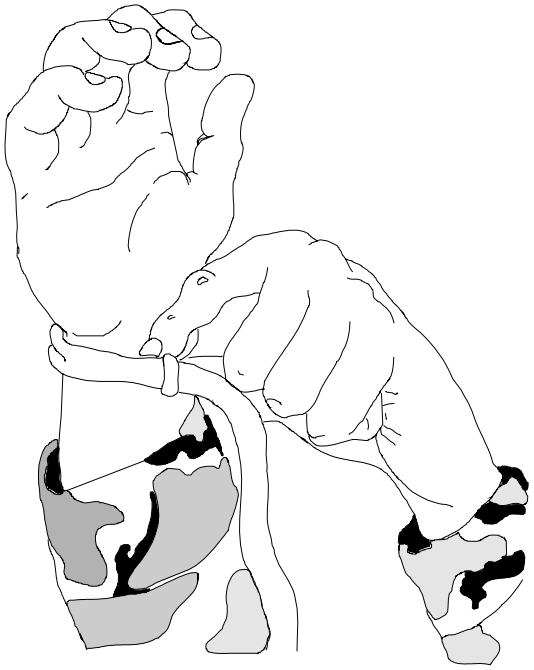


Figure 8-1. Personnel Ground

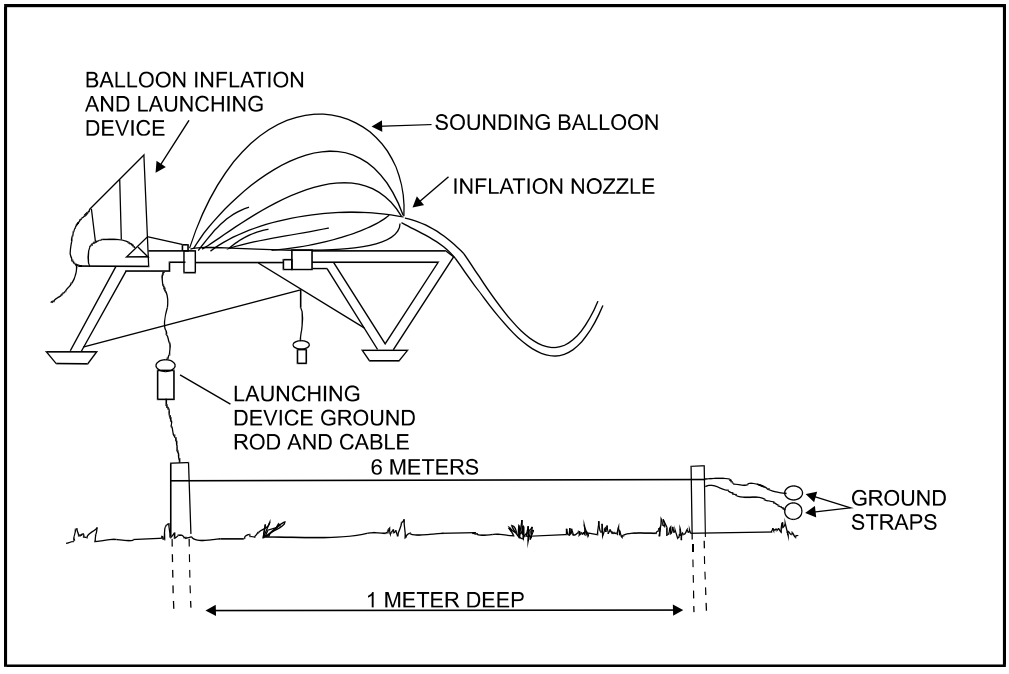


Figure 8-2. Completed Grounding Field

8-3. GASES USED FOR INFLATION

The met section inflates all balloons with either hydrogen or helium gas. Helium and hydrogen are available commercially in compressed gas cylinders. Met sections normally use cylinders containing approximately 200 cubic feet of gas. When compressed gas is not available, the met section must generate hydrogen gas. This is a relatively slow procedure. The met station leader must plan time carefully to ensure that a balloon is fully inflated and ready for release at the scheduled release time.

a. **Helium**. Helium is the safest gas to use because it is not explosive, but it cannot be made artificially. Helium is extracted from mines, stored in heavy cylinders, and shipped in cylinders for met section use. Using commercially produced helium gas to inflate a balloon is quicker and much safer than inflating with locally generated hydrogen; however, it is difficult to re-supply.

b. **Hydrogen**. Because hydrogen gas, unlike helium, is explosive, generating and using it is dangerous. Accordingly, met crew members must follow all safety procedures for use of hydrogen to include using the balloon inflation launching device. Crew members handling hydrogen or its byproducts must be Hazardous Materials (HAZMAT) trained and recertified annually and be highly proficient in generating gas. The met station leader schedules classes on inflation using generated hydrogen gas to maintain section members' proficiency.

8-4. CALCIUM HYDRIDE CHARGES

The calcium hydride charge is an airtight metal can containing calcium hydride. When immersed in water, the charge produces 95 percent pure hydrogen. The top of the can is recessed and has threads for attaching the charge to the bottom of the body of the hydrogen generator. On the top of the can, a number of knockouts are opened to allow water to enter the can.

a. **Types of Charges.** There are two types of calcium hydride charges. The calcium hydride charge ML-305/TM produces approximately 24 cubic feet of hydrogen. This is enough hydrogen to inflate a pilot balloon. Calcium hydride charge ML-587/TM is a larger charge that produces about 42 cubic feet of hydrogen.

b. **Inspection of Charges.** Before each calcium hydride charge is used, a crew member must inspect it to ensure that no corrosion exists along the sealed seams of the container. If there is any corrosion present, the crew member rejects the charge. Corrosion indicates that moisture may have leaked inside the container. An explosion may result if the hand punch used to open the charge causes a spark. In most but not all cases, the calcium hydride charge bulges slightly if moisture has leaked inside and a small amount of hydrogen has formed. Hydrogen gas is highly susceptible to static electricity and may explode. If the crew member observes while gently shaking a charge that the contents are in a lump form or are not in a crystal form, he rejects the charge. Rejected charges are disposed of according to TM 11-2413.

Section II
Hydrogen Generators

WARNING
HYDROGEN GENERATORS PRODUCE HARMFUL BYPRODUCTS. STRICT ENVIRONMENTAL PROCEDURES MUST BE FOLLOWED DURING THE DISPOSAL OF THIS WASTE. SEE APPENDIX H FOR DETAILED INFORMATION.

This section implements STANAG 4168.

8-5. HYDROGEN GENERATOR, ML-303/TM

The hydrogen generator can be used to inflate sounding balloons in the inflation and launching device or to inflate pilot balloons in a sheltered area. The hydrogen generator, ML-303/TM, provides a means for producing hydrogen gas in the field for inflation. The hydrogen generator consists of an outlet tube for attaching hose ML-81, a punch to open the knockout holes in calcium hydride charges, and a generator body that provides a pressure chamber for generated gas.

8-6. HYDROGEN GENERATOR SET, AN/TMQ-3

The set consists of four hydrogen generators, ML-303/TM, mounted on a common manifold, two spare hydrogen generators, ML-303/TM, a packing case, hoses, and a punch. The manifold is a steel tube welded to a square sheet-iron plate, which has four holes for mounting four of the hydrogen generators. The four hydrogen generators are coupled together to permit the section to generate hydrogen at four times the volume of a single generator. The anti-buoyancy bracket assembly holds the hydrogen generator set, AN/TMQ-3, firmly in position during inflation. A crew member fastens the manifold gas outlet to an opening in the center of the bracket assembly. The bracket assembly has an adapter on each end so that the assembly can be secured to the top of the issued 32-gallon galvanized can.

8-7. AN/TMQ-3, HYDROGEN GENERATION

WARNING
DO NOT GENERATE HYDROGEN IN CONFINED SPACES.

A crew member punches out the knockout holes in the top of the calcium hydride charge. He then screws the charge to the bottom of the hydrogen generator. He places the assembly in the water so that the top of the generator is two inches above the water. He agitates the generator periodically so that the lime produced by the chemical reaction does not clog the charge and the generator. When the charge reacts chemically with water, the expanding gas passes through the outlet tube at the top and the generator minimizes the loss of gas from back pressure. A baffle inside the top of the generator prevents water from being forced into the balloon along with the gas. Hose ML-81 provides a connection that allows the gas from the hydrogen generator to inflate the balloon. Care must be taken to ground the hydrogen generator. For detailed information, see TM 11-2413. See Figure 8-3 for an illustration of this process.

a. **Water Usage.** The water needs to be changed after each generation because the waste chemical byproducts associated with the generation process retard the chemical action. Also, the water should be changed because it becomes too hot. Cold water is much more efficient for hydrogen generation.

b. **Limited Water Supply.** If water is hard to obtain, the met section can conserve water by using more than one container. When water must be reused, the section can allow it to stand for about two hours while using a second container of water. When the waste chemicals in the first container have settled, a crew member pours the clear water on the top into a temporary container, cleans the settled waste chemicals from the first container, and refills the first container with the clear water.

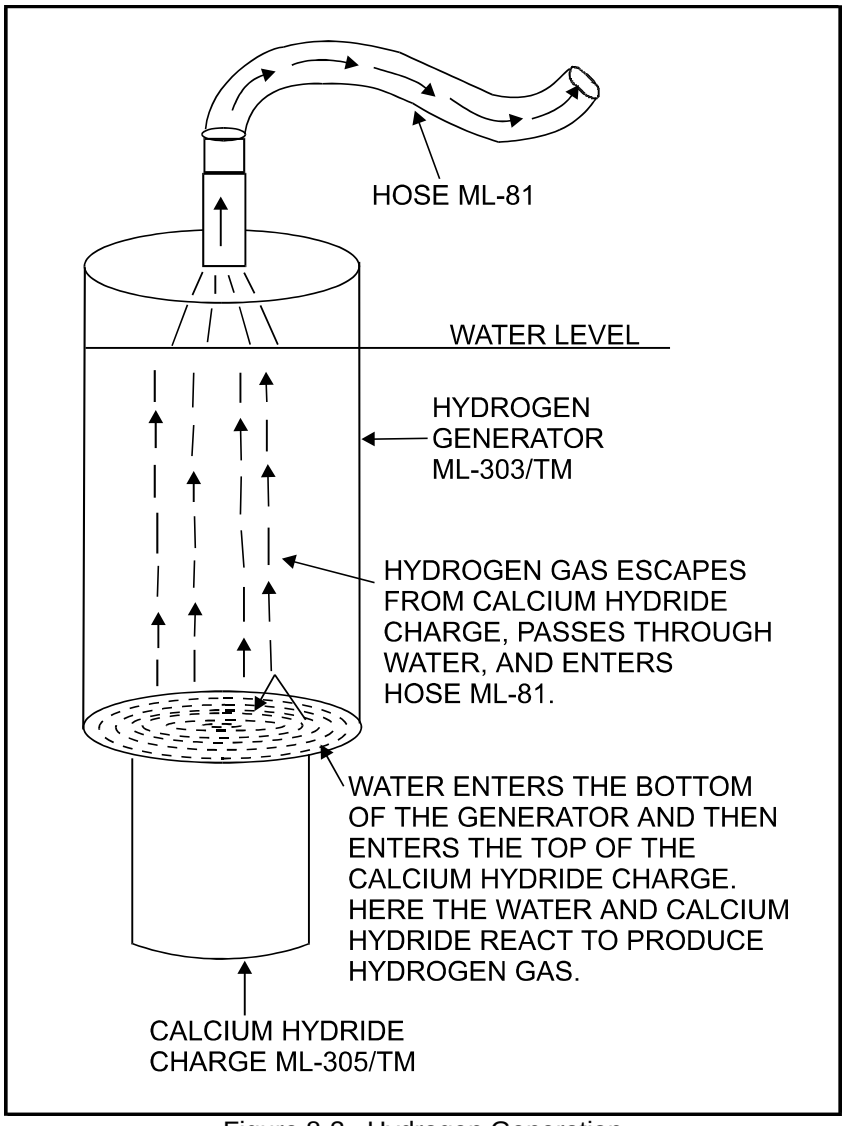


Figure 8-3. Hydrogen Generation

8-8. OPERATOR MAINTENANCE

Operator maintenance of hydrogen generator set, AN/TMQ-3, consists of cleaning the equipment and replacing minor parts. If any active material remains in the generator after inflation is complete, crew members should leave the generator in the water until the charge is expended. This prevents lime from clogging the holes and possibly causing an explosion. Care and maintenance of the hydrogen generator consists mainly of thorough cleaning. Best results are obtained if the equipment is cleaned immediately after use. A crew member must check the perforations in the bottom of the generator and other parts, including hose ML-81, for clogging. He also must check the hose and connections for leaks. If deposits of the chemicals in the water harden on the equipment, they can be removed with a wire brush.

8-9. HYDROGEN GENERATOR, AN/TMQ-42

The AN/TMQ-42 is a truck mounted generator that produces 95 percent pure hydrogen and can store up to 300 cubic feet of hydrogen. It

operates from the section's power plant or from a commercial power source. It can operate at full capacity after a startup period of approximately 30 minutes. Balloons can be filled while the generator is operating or when it is shut down (non-operating generator).

a. **Operating Generator.** If the hydrogen reservoir does not contain enough stored hydrogen, a met crew member can still fill a balloon. The rate of inflation is based on the generator production rate (150 cubic feet per hour). Unwind the balloon fill hose from the hydrogen generator and carry the nozzle to the balloon fill site. Attach the balloon to the nozzle. Open the control valve and at the electronic assembly enter the volume required for inflation. Close the control valve when inflation is complete.

NOTE: Ensure that the hydrogen storage tank contains enough hydrogen gas to fill the balloon before you begin the following procedure.

b. **Non-Operating Generator.** Unwind the balloon fill hose from the generator and carry the nozzle to the balloon filling site. Attach the balloon to the nozzle. Open the control valve at the generator control panel and while watching the volume meter fill the balloon to the desired volume. Close the control valve when inflation is complete.

8-10. PURGING THE HYDROGEN GENERATOR, AN/TMQ-42

Before shipment by air, road movement inside a vehicle, or storage in a building or other enclosed area, the generator must be purged and filled with inert gas. Times for this procedure vary based upon amount of hydrogen, methanol, and methanol mix present in the generator. For this reason the met station leader must consider this in planning for each operation.

Section III
Inflation Procedures

8-11. BALLOON INFLATION AND LAUNCHING DEVICE, ML-594/U

The balloon inflation and launching device, ML-594/U, is a portable inflation shelter and launch platform designed for field use. It secures the sounding balloon and protects it from weather during inflation and launching. It can be used with a compressed gas supply by using the hydrogen-helium volume meter ML-605/U. It should be used whenever hydrogen gas is used for inflation. The balloon inflation and launching device is explained in TM 11-6660-238-15.

8-12. COMMERCIAL GAS REGULATORS

Pressure regulators are used along with associated couplings with commercial hydrogen or helium cylinders to control the pressure of the compressed gas being released for inflation of a balloon. The regulator also indicates the amount of gas remaining in the cylinder. The regulators are adjusted to allow no more than 10 PSI of gas to be released into the balloon.

8-13. BALLOONS

Balloons should be kept sealed in their original containers until just before use. They should be stored in a dry place and at moderate temperatures. All balloons deteriorate with age; therefore, oldest balloons should be used first.

a. **Sounding Balloon.** The sounding balloon carries aloft a radiosonde and associated equipment, such as a parachute and a night-lighting unit. Sounding balloons are made of neoprene and are designed to lift radiosondes to certain minimum altitudes at specified rates of ascent. The bursting altitude of a sounding balloon depends on its condition and type and on the inflation procedure used. High-altitude balloons weigh 1,000 to 1,200 grams and burst near an altitude of 32,000 meters. At night, the

balloons normally burst at lower altitudes. Bursting altitudes are with respect to mean sea level.

b**. Pilot Balloon.** This balloon provides a means of determining the speed and direction of winds aloft. The 100-gram pilot balloon also can be used as a sounding balloon up to 3,000 meters. The theodolite operator can observe a pilot balloon to a height of about 14,000 meters. Under various sky condi-tions, some colors are more easily detected by the eye than others. For this reason, pilot balloons are issued in several colors. The most common colors are white, red, and black. A general rule in selecting the color of the balloon is the darker the sky, the darker the balloon.

8-14. PREPARATION OF BALLOONS

After exposure to relatively low temperatures and extended periods in storage, neoprene balloons lose some of their elasticity through the crystallization of the balloon film. Neoprene balloons burst prematurely if used in this state. Met personnel should inspect balloons prior to their use and discard any that are brittle-especially when using hydrogen. Met personnel should also discard any balloons older than five years.

a. **Balloon Conditioning**. Usually, exposure of the balloon to room temperature (21°C) for 24 hours is all the conditioning required. Store balloons in their sealed package and do not expose to direct light or heat. Discoloration has no effect on the balloon film as long as it is not the result of exposure to direct sunlight for several hours. In direct sunlight and in most types of artificial lighting, discoloration is caused by the antioxidant included in the compounding.

b. **Inflation**. A balloon may be inflated immediately after conditioning, or it may be kept under normal storage conditions and then inflated. All balloons should be at room temperature before inflation.

8-15. NIGHT-LIGHTING UNIT

The night-lighting unit provides a light source that allows the tracking of pilot and sounding balloons at night. There are two types of night-lighting units. Met sections may be required to use either type. One type consists of a water-activated battery and a bulb. The other type is called a light stick. A light stick is a small transparent tube containing a liquid chemical. When the light stick is snapped, the chemical begins to emit enough light for tracking balloons.

8-16. DETERMINING LIFT FOR BALLOONS

A crew member determines the amount of gas required for the balloon to be used before beginning the inflation process. He uses the procedure below to determine the amount of gas required.

a**. Determining Required Free Lift.** Free lift is the net upward force required for the balloon to ascend at a given rate. The ascent rate of the balloon mainly depends on the amount of gas in the balloon. Other factors affecting ascent rate are the shape, size, and physical texture of the balloon and the state of the atmosphere through which the balloon travels. Table 8-1 is used to determine the amount of free lift for sounding and pilot balloons during fair weather.

BALLOON TYPE	ASCENT RATE (METERS PER MINUTE)	FREE LIFT WEIGHT (GRAMS)	BALLOON WEIGHT (GRAMS)	BURSTING ALTITUDE (METERS)
SOUNDING BALLOONS				
(DAY)				
ML-635	400	1,100	150	10,668
ML-537	305	1,600	1,000	30,479
ML-519	300	1,200	300	16,000
(NIGHT)				
ML-635	400	1,300	150	10,668
ML-537	305	1,900	1,000	30,479
ML-519	300	1,200	300	16,000
PILOT BALLOONS				
ML-159A (WHITE)	302	500	100	15,000
ML-160A (BLACK)	302	500	100	15,000
ML-161A (RED)	302	500	100	15,000
ML-50A (WHITE)	183	140	30	10,000
ML-51A9 (BLACK)	183	140	30	10,000
ML-64A (RED)	183	140	30	10,000

Table 8-1. Balloon Ascent Rate, Free Lift, Weight, and Bursting Altitude

b**. Computing Required Total Lift.** Total lift is defined as the weight (grams) of the balloon with attachments that must be balanced by the gas volume in the inflated balloon for the balloon to rise at a desired rate. Total lift is comprised of the weight of the balloon, its free lift, the weight of any attachment to the balloon train, and the weight added, if any, to compensate for adverse weather. See Table 8-2 for weights of attachments. Table 8-3 indicates additional weights needed to compensate for adverse weather conditions.

8-17. DETERMINING GAS VOLUME REQUIRED

To obtain the proper amount of gas required for total lift, a crew member must convert total lift in grams to cubic feet. He does this by using the nomograph (Figure 8-4).

a. **Total Lift Less Than 3,000 Grams**. If total lift is from 1,400 to 3,000 grams, he enters the nomograph with total lift in grams along the **left** edge. He reads across to the line on the chart that represents the gas to be used (helium or hydrogen) and then **down** from the line to the metered cubic feet required for total lift.

ATTACHMENT	WEIGHT (GRAMS)
RADIOSONDE with Battery	
ML 659	823
ML 662	250
ML 663	250
ML 664	250
ML 665	450
ML 666	450
ML 667	450
PARACHUTE	
ML-132	150
ML-	80
LAUNCHING REEL ML-367	100
LIGHTING UNIT	15
BALLOONS	
SOUNDING:	
ML-635	150
ML-537	1,000
ML-519	300
PIBAL:	
ML-159A	100
ML-160A	100
ML-161A	100
ML-50A	30
ML-51A	30
ML-64A	30
NOTE: BALLOON WEIGHTS VARY. THE WEIGHT OF THE BALLOON IS STAMPED ON ITS BOX.	

Table 8-2. Weights of Attachments

WEATHER CONDITIONS	ADDITIONAL WEIGHT REQUIRED (GRAMS)
Light precipitation	200
Heavy precipitation	400
Zone winds averaging more than 60 knots (1,000-gram or larger balloons only)	600 to 1,200

Table 8-3. Additional Weights for Adverse Weather Conditions

b. **Total Lift Greater Than 3,100 Grams**. If total lift is 3,100 grams or greater, he enters the nomograph with total lift along the **right** edge. He reads across to the line on the chart that represents the gas to be used (helium or hydrogen) and then **up** from the line to the metered cubic feet required for total lift.

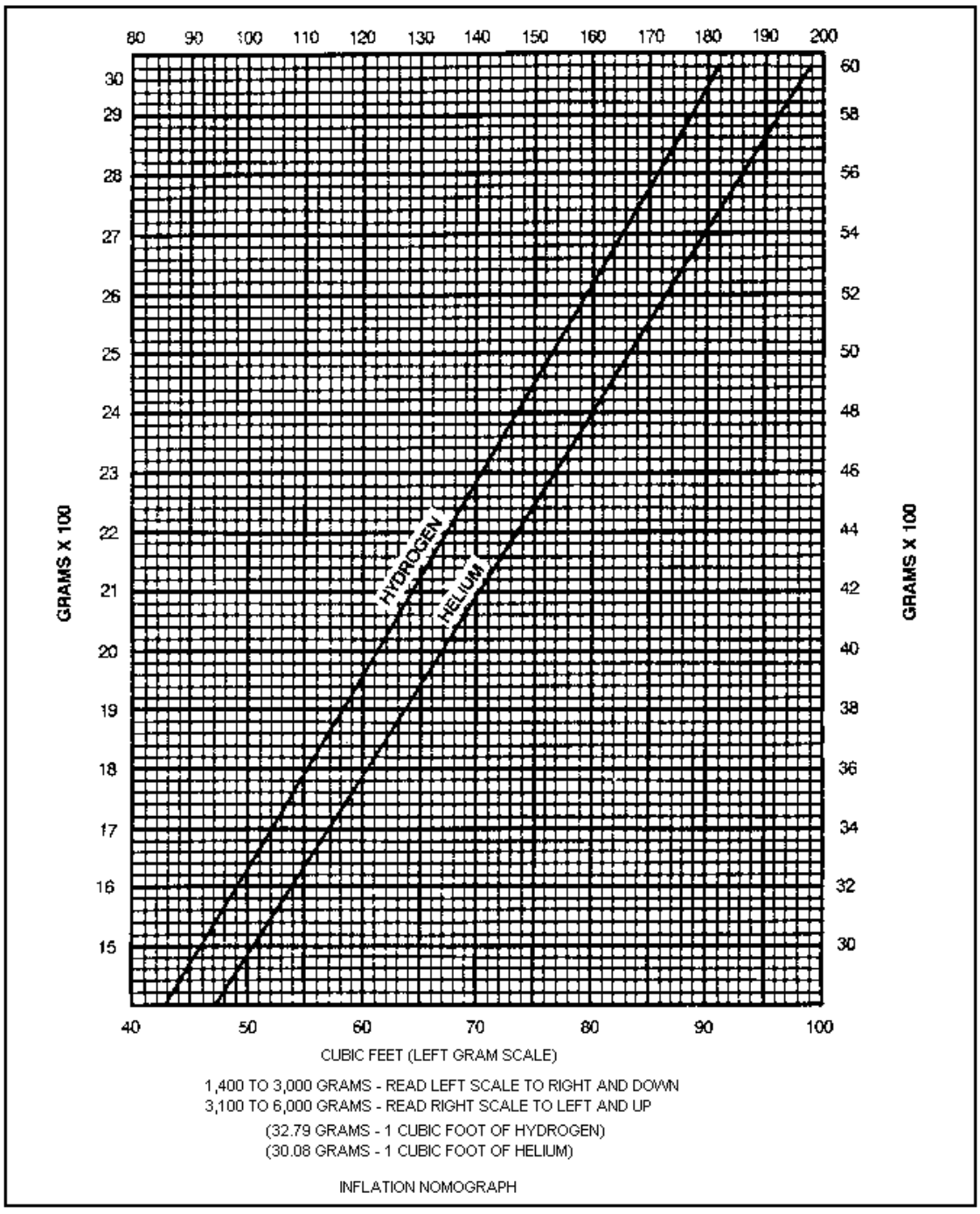


Figure 8-4. Inflation Nomograph

8-18. INFLATION USING THE INFLATION AND LAUNCHING DEVICE

The inflation and launching device should be used when inflating with hydrogen. When the inflation launching device is used, the crew members inflate the sounding balloon with the required amount of gas volume determined from the nomograph. See Figure 8-5 for an example.

a. **Commercial Gas**. When crew members use commercial gas for inflation, they obtain the correct total lift by inflating the balloon until the volume meter ML-605/U reads the cubic feet required as determined from the nomograph.

b. **Calcium Hydride Charges.** If crew members use calcium hydride, they must determine the number of calcium hydride charges needed to produce the required amount of gas, since the volume meter cannot be used. They use the amount of gas produced by each type of calcium hydride charge to determine the number and type charges required.

c. **Hydrogen Generator, AN/TMQ-42**. When the hydrogen generator, AM/TMQ-42, is used, the meter located on the control panel of the generator is used to determine when the balloon is properly inflated.

8-19. INFLATION SHELTER

There may be times when a met station is in a fixed position and has some type of inflation shelter. If an inflation shelter is available, met section personnel do not use the inflation and launching device. The section uses an inflation shelter, i.e., the covered cargo area of a prime mover, to inflate the small pilot balloon.

a. **Weighing-off Procedure**. When an inflation shelter is used for inflation, the crew members determine when the balloon is properly inflated by using a weighing-off procedure. A crew member attaches the balloon to an inflation nozzle with appropriate weights to simulate the effect of free lift and the weight of the balloon train. When the sounding balloon lifts the inflation nozzle off the surface, it is properly inflated. The pilot balloon is properly inflated when it hangs suspended in midair, neither rising nor falling.

An example of the computation of the total lift required for a typical daytime radiosonde ML-659 flight using balloon ML-537/UM is as follows.	
Balloon ML-537 (Table 8-1)	1,000 grams
Required free lift (Table 8-1)	1,600 grams
Weight of radiosonde and parachute (Table 8-2)	973 grams
Total lift required	3,573 grams
Total lift expressed to next higher 100 grams	3,600 grams
The total lift is 3,600 grams and the compressed gas being used is helium. From the nomograph (Figure 8-4) 3,600 grams equals 120 cubic feet. Thus, the operator meters 120 cubic feet of compressed gas.	

Figure 8-5. Required Total Lift Example

b. **Weigh-off Calculations**. To achieve weigh-off, a crew member must calculate the required weights to be added to the inflation nozzle. For example, to calculate the weight required to be added to the ML-196 nozzle of a sounding balloon, a crew member must determine total lift. The weight of the balloon is not figured in the total weight because as the balloon is inflated it automatically compensates for itself. The nozzle weight (1,500 grams) is deducted, and the remainder is the additional weight required to be placed on the nozzle. The nozzle weights are 100, 200, 400, 500, and 1,000 grams. See Figure 8-6 for an example.

8-20. NOZZLES AND WEIGHTS

Inflation nozzle ML-575, ML-373/GM, and ML-196 are component parts of the met station. They are used in the weighing-off procedure performed in an inflation shelter or in an area of still air. They provide a connection between the hose ML-81 and the balloon during inflation and act as a calibrated weight in determining the correct amount of total lift during weigh-off.

a. **Pilot Balloon Nozzles.** Nozzles ML-575 or ML-373 are used to inflate the pilot balloon. The correct free lift for a 100-gram pilot balloon is 500 grams. The ML-575 and the ML-373 with its collar weight compensates for the free lift.

b. **Sounding Balloon Nozzle.** The inflation nozzle ML-196 weighs 1,500 grams and is issued with five weights. A crew member must add the correct combination of weights to the nozzle to simulate free lift and balloon train weight before inflation.

c. **Nozzle Care**. Crew members must keep the nozzles free of dirt, lime, or other foreign matter that will alter its weight or obstruct the gas passages.

8-21. INFLATING THE PILOT BALLOON

A crew member first shakes the balloon to remove the powder inside and rolls it up to expel any air. To expel the air from the connections to the generator after the hose and nozzle are connected, a crew member allows the hydrogen from the hydrogen generator to escape through the passages into the air, thus clearing the hose and nozzle. The balloon is weighed-off properly when it hangs suspended in midair with appropriate weights attached. When inflating the pilot balloon, a crew member must first install weights, when required, on the neck of the nozzle. If a night-lighting device is to be attached to the balloon, he must add additional weights to the nozzle to compensate for the greater air resistance caused by the increased size of the balloon. The additional weights required are 70 grams for the 30-gram pilot balloon and 50 grams for the 100-gram pilot balloon. Once he has added the weights to the nozzle, he then stretches the neck of the balloon over the connection of the nozzle.

To achieve weigh-off, a crew member calculates the following:	
Total lift required	3,600 grams
Minus the weight of the balloon	-1,000 grams
Minus the weight of nozzle ML-196	-1,500 grams
Additional weight required	-1,100 grams
Thus, a crew member adds the 1,000- and the 100-gram weights to the nozzle and attaches them to the balloon to equal the required total lift. When he has allowed enough gas to flow into the balloon to cause the balloon to just lift the inflation nozzle with weights off the ground, the inflation is completed.	

Figure 8-6. Weigh-off Example

8-22. INFLATING THE SOUNDING BALLOON

The procedures for inflating the sounding balloon when using the inflation and launching device and when using an inflation shelter are discussed below.

a. **Inflation and Launching Device.** The inflation and launching device should be used

when inflating with hydrogen. A crew member first shakes the balloon to remove the powder inside and rolls it up to expel any air. To inflate the sounding balloon with the required volume of gas, crew members use the procedure in TM 11-6660-238-15. Crew members must fill the balloon with gas by using the volume meter, the meter on the control panel of the hydrogen generator, or by attaching the required number of charges to the AN/TMQ-3.

b. **Inflation Shelter**. A crew member first shakes the balloon to remove the powder inside and rolls it up to expel any air. He attaches the balloon to the inflation nozzle by tying it with a small piece of twine. He then attaches to the inflation nozzle the combination of weights required to balance the required total lift.

8-23. TYING OFF THE BALLOON

When inflation of either the pilot balloon or the sounding balloon is complete, the crew member firmly seals the balloon neck with twine and disconnects the hose from the inflation nozzle. He then removes the inflation nozzle and any weights used from the tied off balloon. He is then ready to attach the balloon train to the balloon, if one is required. Figure 8-7 shows the correct tying off procedures.

8-24. BALLOON TRAIN

The balloon train is the trailing end of the twine used to seal or tie off the inflated balloon. Components such as the radiosonde and parachute are further attached to the balloon train and become a part of it. A night-lighting device may be included in the train between the parachute and the radio-sonde to aid initial tracking of the balloon-borne radiosonde. The balloon train is nor-mally approximately 20 meters long in order to dampen the oscillation of the radiosonde.

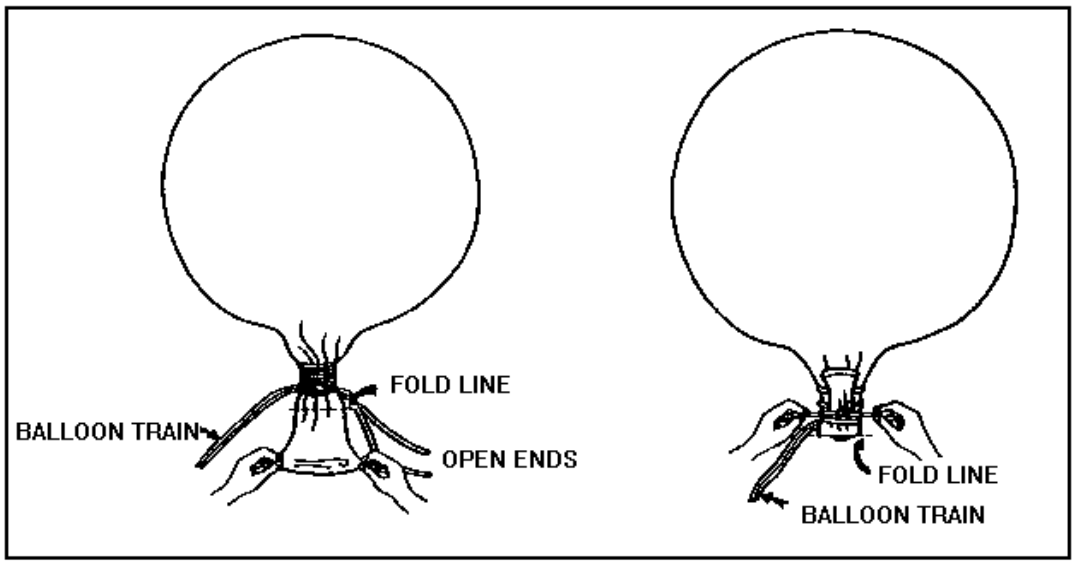


Figure 8-7. Tying Off the Balloon

When a crew member has properly inflated the balloon, he removes the inflation nozzle and seals and ties off the balloon. He doubles a 20-meter length of twine to a 10-meter length (double strength). He ties and seals the neck of the balloon with the open end of the twine. Next, unless he is in an active theater of operations, he secures the parachute to the closed end of the doubled twine. Normally, the parachute is not used in combat operations. He then doubles another 20-meter length of twine, secures the open end to the bottom of the parachute suspension lines, and ties the radiosonde to the closed end. If the radiosonde being used has an unwinder, the crew member shortens the length of twine from the balloon to the parachute

to approximately one meter and ties the radiosonde directly to the parachute suspension lines. In moderate to high winds, twine should be manually unwound and secured to prevent damage to the radiosonde during release. Figure 8-8 shows the balloon train.

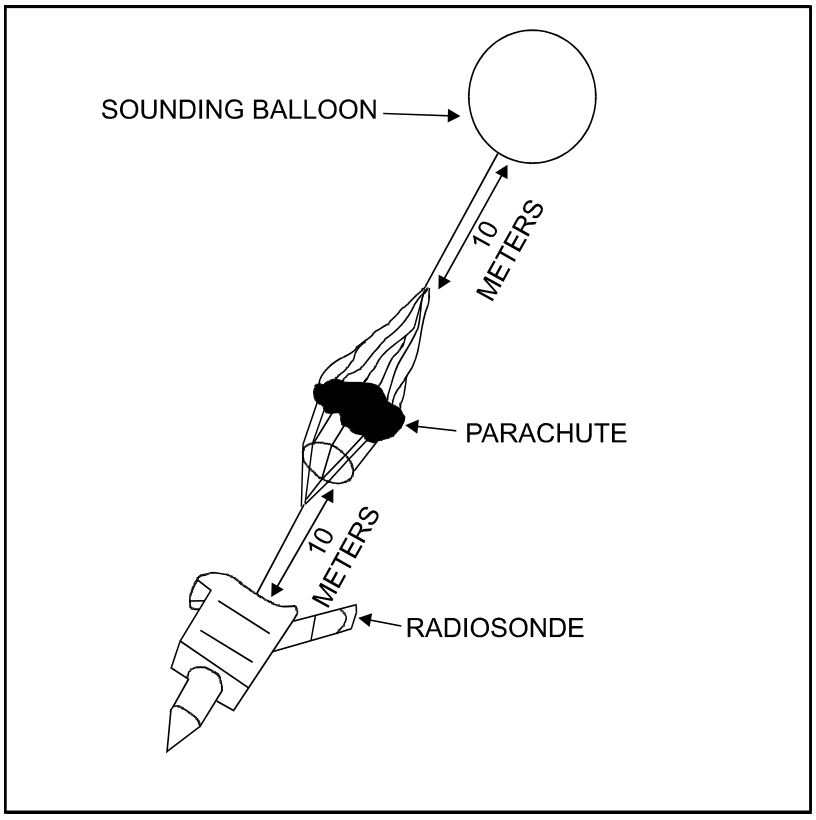


Figure 8-8. Balloon Train

Section IV
Release Procedures

WARNING
WHEN PREPARING TO RELEASE A HYDROGEN FILLED BALLOON, ENSURE THE WIND WILL NOT CARRY THE BALLOON OVER THE OPERATING HYDROGEN GENERATOR. THE EXHAUST GAS FROM THE CHIMNEY COULD IGNITE THE BALLOON OR CAUSE THE BALLOON TO EXPLODE.

8-25. GENERAL

NOTE: If operating in the vicinity of an airfield, notify the air traffic control tower prior to balloon release.

Because of the time it takes to prepare each sounding and the cost of the components, the met section crew members must make every effort to release a balloon without damaging the components. Damaging the train during release causes disruption of the scheduled release times. This could affect the mission of the artillery. There are several release methods. Which method to use depends on the surface weather conditions at the time of release. The release methods for the balloon train are discussed below. They should be followed to ensure that the balloon train release is achieved without damaging any component.

8-26. RELEASING FROM THE INFLATION AND LAUNCHING DEVICE

During periods of no wind, one crew member can release the balloon train by using the inflation and launching device; however, release normally requires two or more persons. During periods of moderate winds, two crew members release the balloon train. If there are high winds and/or rain or if the section is using a larger sounding balloon, off-duty shift crew members may need to help in the release. After the balloon is inflated, crew members move the inflation and launching device with the balloon train attached downwind and position it with the front of the inflation and launching device pointing downwind. If there are high winds, they may have to stake the skids of the inflation and launching device to the ground to ensure stability. Just before release, a crew member removes the safety strap from the lift dot fastener stud and manually positions the release strap fastener in the groove on the stud to ensure that the proper release action will occur. When the section is ready to release, a crew member takes the radiosonde part of the balloon train downwind from the inflation and launching device. The crew member holding the radiosonde pulls on the radiosonde end of the balloon train. This action frees the master loop and allows the end of the canopy to open. When the canopy opens, the balloon is released. When the balloon has risen to an altitude where the balloon train supports the attached components clear of the ground, the release of the radiosonde is completed and the sounding is underway. Figure 8-9 shows a release from the inflation and launching device.

8-27. RELEASING FROM AN INFLATION SHELTER

When the section uses an inflation shelter to inflate the balloon, the crew members release the balloon by using either the hand-over-hand method or the two-man running-release method.

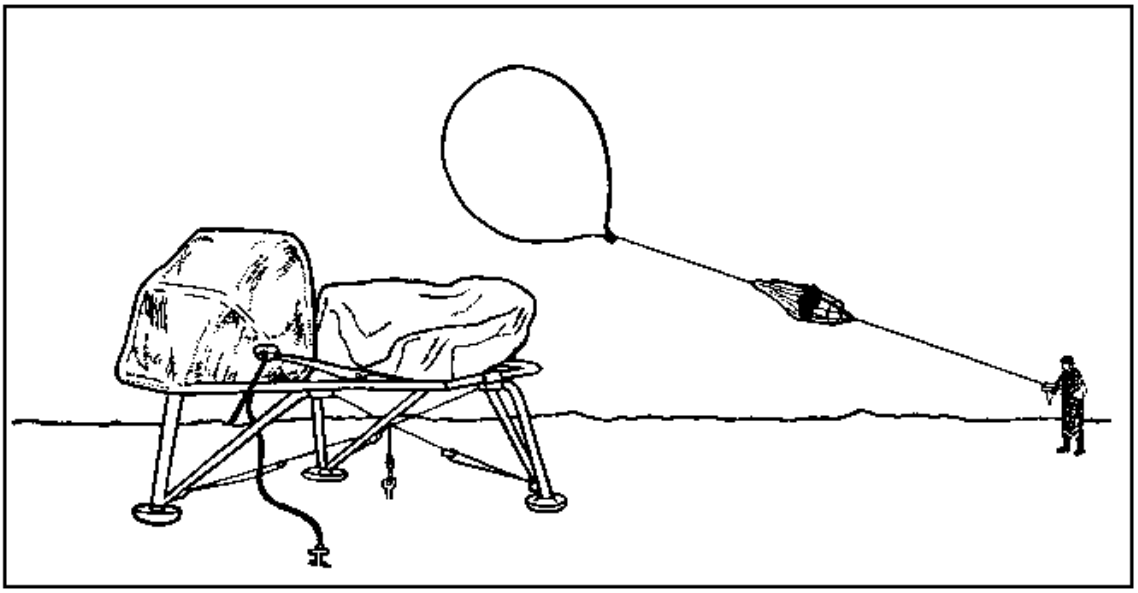


Figure 8-9. Release from the Inflation and Launching Device

a. **Hand-Over-Hand**. The section uses the hand-over-hand method when the surface winds are relatively calm. Normally, use of this method of release requires two crew members. One crew member takes the radiosonde and moves downwind until the length of the train is taut. He serves as the balloon train anchor until time of release. The second crew member grasps the balloon by the neck and removes the balloon from the inflation shelter. He then plays out the balloon and its attached train in a hand-over-hand fashion, moving toward the first crew member and keeping the twine taut until the radiosonde is lifted off the ground.

NOTE: Do not use this method with a hydrogen-filled balloon.

b. **Two-Man Running Release.** The section uses the two-man running-release method in moderate to high winds. One crew member holds the balloon neck. Another crew member holds the radiosonde upright and assumes a position the full length of the train downwind from the balloon. The first crew member releases the balloon at the given signal, and as the balloon rises, the crew member holding the radiosonde runs with it while trying to keep the train taut and maintain a position downwind of the rising balloon. When the balloon is directly overhead and the train is taut, the crew member holding the radiosonde allows the balloon to lift the radiosonde from his hands.

8-28. RELEASE USING A LAUNCHING REEL

When the launching reel is used, a crew member ties the parachute close to the balloon. He ties the eyelet end of the launching reel directly to the parachute suspension lines. He wraps the unwound end of the reel cord around the spacer roller and ties it to the radiosonde. One crew member holds the radiosonde and another crew member removes the balloon from the area of the inflation shelter, thus allowing the immediate release of the balloon train. Once the balloon is in the air, the reel permits the twine to feed out slowly until the train length is approximately 20 meters. However, when a launching reel is used and surface winds are very high, the balloon train may be shorter than its normal 20-meter length.

8-29. RELEASE USING A BALLOON SHROUD

NOTE: Do not use the balloon shroud with a hydrogen-filled balloon.

When using the inflation shelter in moderate to high wind conditions, the crew member may choose to use the shroud to aid in the release of the balloon train. The shroud is designed to protect the sounding balloon while it is being moved to the point of release and to aid in releasing it under high wind conditions. The shroud consists of a hood, four flaps (each of which terminate in a D handle), and a top cord. The procedure for releasing a balloon by using a balloon shroud is discussed below.

a. **Shroud Positioning**. To place the balloon in the shroud, a crew member must lower the balloon as close as possible to the ground. He then places two of the shroud flaps over one side of the balloon and allows the balloon to rise under the shroud. He attaches the top cord to the loop at the top of the shroud so that he can handle the bottom end of the top cord. The crew member holds the four D handles with one hand and the top cord with the other and moves the balloon to the release point. Ordinarily, the balloon can be moved to the release point by one crew member holding the D handles and the top cord while a second crew member carries the radiosonde and parachute. In very high winds, two crew members are needed to hold the balloon, one to hold the top cord and the other to hold the D handles.

NOTE: To prevent accidental loss of the shroud if all four D handles are released, the top cord should be tied to the crew member releasing the balloon.

b. **Release Procedure**. Normally, one crew member holds the shroud while the other crew member holds the radiosonde downwind from the balloon. The crew member holding the shroud releases the front two D handles at the same time while continuing to hold the rear two D handles and the top cord. The balloon slides out from under the shroud. As the balloon ascends, the second crew member maintains a position directly under the drifting balloon until the radiosonde lifts from his hands. Figure 8-10 shows a release using a shroud.

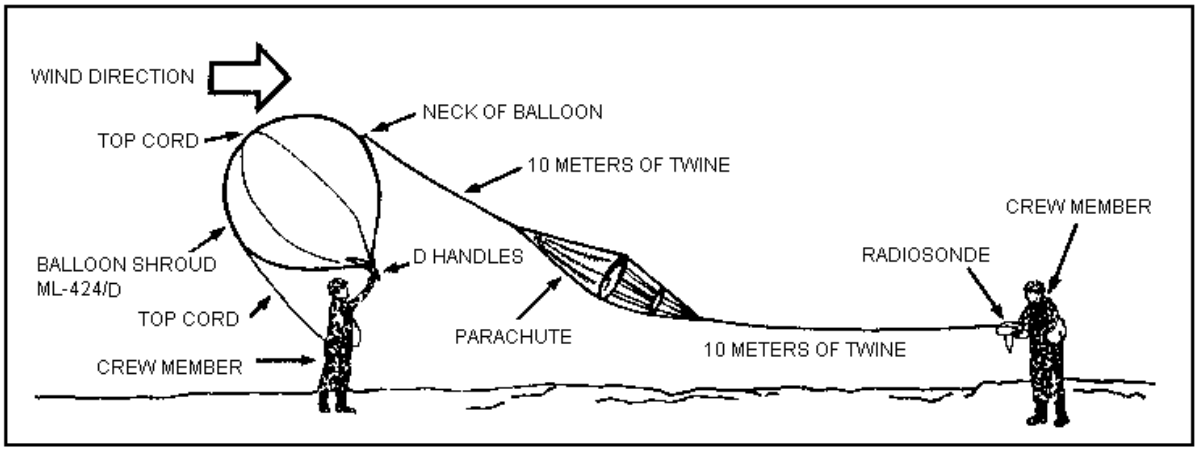


Figure 8-10. Release Using a Shroud

Chapter 9
Personnel, Logistics, and Maintenance

Manning, fixing, and sustaining the force is essential for effective combat operations. Sound planning is essential so that met support is always available in the area of operations. Planning is done at corps artillery, division artillery, and field artillery brigade to ensure met sections receive adequate and timely support. This chapter focuses on logistic planning considerations that are the responsibility of the met station leader and his operational supervisors.

9-1. PERSONNEL

Strength accounting is the process by which personnel combat readiness is measured. It keeps track of the troops on hand, identifies those that have been lost, and identifies those that are needed.

a**. Readiness Management.** Commanders must be very cautious when filling vacancies for the met personnel because of the low density and criticality of the 93F MOS. Commanders must request personnel far enough in advance to ensure a smooth rotation of met personnel. Further care must be taken to ensure that the request for repair personnel (93FlOHl, 93F2OHl) contains the required additional skill identifier (ASI) of Hl after the base MOS. If the Hl ASI is not annotated, only met crew members without maintenance training will be received by the unit. This leaves the met section without the required maintenance personnel to repair the met equipment. All requests for replacements and evacuation reporting should be handled by the unit S1. All shortages of positions that require the H1 ASI should be reported as critical.

b. **Sustaining Soldiers**. Commanders and met station leaders must diligently manage and execute sustainment support for met personnel. Oftentimes the met section is not with its parent organization; therefore, timely food, medical, chaplain, pay, and postal services must be provided to ensure soldier morale and combat effectiveness. Met station leaders must coordinate with supported units for this support. Met station leaders must also direct the health and welfare activities of section personnel. These include but are not limited to the following:

(1) Coordinate for food, water, and other life support.

(2) Inspect soldier's personal hygiene.

(3) Inspect soldier's personal gear.

(4) Ensure medical problems are promptly attended.

(5) Schedule rest periods.

9-2. LOGISTIC PLANNING

Logistic planning must include the requirements for sustaining met sections during extended combat operations. The logistic plan based on adequate and timely support of the tactical operation must be complete, simple, and flexible. Logistic planning must address the following:

- Movement and load planning.
- Basic loads and stockage levels.
- Supply channels and location of reserve stocks.
- Communications.
- Maintenance concept.

9-3. BASIC LOAD AND STOCKAGE LEVELS

a. **Basic Load**. A met section basic load is the amount of expendables (radiosondes, balloons, parachutes, and so forth) required to sustain combat operations for seven days.

Basic loads for met sections are determined by the amount of expendables needed for the maximum number of balloon releases per section per day of operations. A met section can run one flight per hour, up to a maximum of 18 flights per day. Each section is allocated six hours per day for maintenance and movement. The maximum numbers of flights cited here are for intense battle only. The cost of expendables precludes the maximum number of flights being flown for training.

b. **Stockage Levels.** Current authorized stockage levels are listed in TM 11-6660-218-20P and TM 11-6660-283-13.

9-4. LOGISTICAL SUPPLY CHANNELS AND LOCATIONS OF RESERVE STOCKS

a. **Supply Channels.** With current authorizations of vehicles and personnel, each met section can only transport a seven-day supply of expendables. As supplies are expended, resupply must be done by the division support command (DISCOM). Maneuver experience factors indicate that the DISCOM should keep a 14-day supply level per met section and the corps support command (COSCOM) should keep a 30-day supply level per met section. Besides met-peculiar expendables, met sections equipped with the AN/TMQ-3 hydrogen generator may consume up to 400 gallons of water per day to produce hydrogen gas for balloon inflation.

b. **Resupply Publications.** The nomenclature and quantities of items authorized per met section are in TM 11-6660-265-10-HR, TM 11-6660-218-20P, and TM 11-6660-283-13. Because met section expendables are very low-density items, division and corps stockage levels must be carefully monitored. Careful management prevents exhaustion of supplies and subsequent interruption of met support on the battlefield.

c. **Additional Resupply.** Met sections require other forms of supplies. The most important supplies are petroleum, oils, and lubricants (POL); spare parts; food; water; and ammunition. It is very important that all aspects of resupply are considered when developing the resupply rate for met sections. The met station leader must develop proper usage rates for all supplies to ensure smooth, continuous operations.

9-5. COMMUNICATIONS

For the met section to achieve its mission, communications must be established quickly and maintained. Primary references for met section communications are TM 11-5820-401-10-1 and -2. The met station leader must ensure all members of the section are properly trained in correct communications procedures and on section communications equipment. The met section point of contact for communications requirements and training is the unit signal officer. The met station leader is responsible for maintaining all aspects of communications to include the following:

- Familiarity with the unit signal operating instructions (SOI).
- Communication systems initialization and setup.
- Assigned frequencies.
- Encryption procedures.
- Radio procedures.
- Communications security.
- Message development and emergency procedures.
- Alternate forms of communication.

9-6. MAINTENANCE CONCEPT

There is one maintenance standard. This standard is based on TM 10 and 20 series preventive maintenance checks and services (PMCS). The goal of all levels of maintenance is to limit the downtime of equipment. The objective of maintenance in combat is to fix as far forward as possible.

a. **Unit Level Maintenance.** Unit level maintenance is the most critical. Unit level maintenance consists of the operator and met equipment repairer.

(1) Operator maintenance includes the following:

- Before, during, and after operations checks.
- PMCS.
- Scheduled maintenance.

(2) Met equipment repairer maintenance consists of the following:

- Visual inspections.
- Execution of diagnostic programs.
- Services and replacements as authorized by the maintenance allocation chart (MAC).
- Scheduled and unscheduled maintenance, to include adjustments and alignments authorized by the MAC.

Unscheduled maintenance includes diagnosis and fault isolation as authorized by the MAC. To analyze malfunctions, the trained mechanics in the met section use built-in test equipment (BITE) along with appropriate technical manuals.

b. **Direct Support Maintenance.** Direct support (DS) maintenance is performed by the supporting DS maintenance unit. DS electronic repair personnel provide required maintenance support when maintenance falls outside the echelon of the met section repairer. Most DS repair is performed on-site at the met section location. If repair cannot be performed on-site or the problem requires equipment evacuation to a higher level, the met equipment is evacuated to its supporting DS unit by the most appropriate method. This can be done by the unit supply section or S4. Because of the low density of met equipment and the difficulty in procuring repair parts, the DS unit must keep an adequate stockage of repair items. This prevents long downtimes due to unavailability of parts.

c. **General Support.** General support (GS) maintenance is not used for met systems peculiar items; however, GS maintenance is required for associated items of support. Met peculiar equipment that cannot be repaired at the DS level must be evacuated to depot. Non-met peculiar items undergo GS maintenance as identified on their particular maintenance allocation chart.

d. **Depot.** The depot repairs those modules and assemblies that are beyond field-level capability and overhauls or rebuilds met equipment as required.

e. **Software Maintenance (Computer Programs)**. Computer software is the responsibility of Headquarters, Communications-Electronics Command (CECOM), at Fort Monmouth, NJ. CECOM will distribute updated programs to the user as changes are made. **Personnel in field units will not create computer programs or update existing programs.**

Appendix A
Met Messages

This appendix implements STANAG 4061, STANAG 4082, STANAG 4131, STANAG 4140, and QSTAG 1166.

All met messages are coded in a format that is recognized and used by United States and allied forces and weather services worldwide. These formats are mandated by several standardization agreements and quadripartite standardization agreements and the World Meteorological Organization. This appendix discusses these messages.

Section I
FATDS Met Messages

A-1. GENERAL

Digital transmission is the primary means of sending met messages to FA units. The met section contains field artillery tactical data system (FATDS) formats for all met messages. Met messages are sent to FA firing units and FSEs, as required. The met messages normally are transmitted to the divarty fire control element (FCE). The communications aspect (message address, message source, and authentication) of data transmission is in the first message element, the communications (comm) line. There are two format differences between a digital met message and a standard met message. The first is the comm line, which is required to transmit the message. The second difference is the format of the met data provided, which is by data line. FATDSs store only the most recent met messages from a met section, but hard copies of all others can be produced.

A-2. MET MESSAGE COMM LINE

The first line of every message segment is the comm line. The comm line contains the same information for all met messages. The comm line consists of nine parts. Each part has a field. A semicolon separates each field. The format of the comm line is shown in Figure A-1. The numbers above the comm line format indicate position spaces only (72 total). These numbers are not part of the message.

a. **Header**. The first six character positions in the comm line comprise the header field. The first six positions are entry variables. The semicolon (seventh position) signifies the end of the header. The format for the comm line header is shown in Figure A-2.

(1) **Destination**. The first position in the header field shows the destination of the message. On a received message, the first position shows the sender. Normally, the divarty FCE is the addressee. However, specific FDCs may be addressed by using any letter or number, as specified by the controlling FDC or FCE, SOI, or standing operating procedures (SOP).

```
          1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789012
_ _ _ _ _ _ _ ; P : _ ; S B : _ / _ / _ / _ _ _ _ _ ; C : _ _ _ _ _ ; S G : _ _ , _ _ ; D T : _ _ , _ _ / _ _ / _ _ ; I D : _ _ _ _ ; A : _ ; _
```

Figure A-1. Comm Line Format

```
1  2  3  4  5  6  7
_  _  _  _  _  _  ;
```

Figure A-2. Comm Line Header Format

(2) **Transmission Repeat Number**. The second position contains the transmission repeat number (TRN). The TRN is first set to zero. The TRN is advanced by one digit each time the message is retransmitted. After four unsuccessful transmissions, voice contact is required to determine the problem.

(3) **Authentication Characters**. Positions 3 and 4 are the authentication or serialization characters. These characters are the next unused authentication codes. If no acknow-ledgment is received, the next set of numbers is used and the TRN is advanced one number.

(4) **Message Type**. The message type (position 5) is a single number that represents the type of message being composed for transmission or processing. The message type must be entered in the header by the operator when he composes the message. Met messages are always type 3.

(5) **Message Source**. The message source character (position 6) represents the source that transmitted the message as specified by the controlling FDC or FCE, the SOI, or the SOP. The source character for a message originated by a met section is entered during initialization.

b. **Priority**. The message priority is determined by the message category and type. It is specified by the controlling FDC at the time of loading or system initialization. The priority scheme is numbered from 1 to 8, with 1 being highest priority. Message priority should not be altered by the met system operator. The priority field occupies positions 8 through 11. Its format in the comm line is shown in Figure A-3.

```
          1
8  9  0  1
```

```
P  :  _  ;
```

Figure A-3. Priority Field Format

c. **Subscriber**. The subscriber is the logical name of the recipient of the message. The subscriber is specified by SOI or divarty SOP. The subscriber field (Figure A-4) occupies positions 12 through 27 in the comm line and consists of five separate subfields (indicated by slashes and commas). The first subfield (position 15) is the section number, and the second (position 17) is the platoon number. These two subfields are not used for all subscribers. The third subfield (position 19) designates the battery. The fourth subfield designates the battalion and has two positions (21 and 22) for numbers. The fifth subfield designates the regiment and has three positions (24, 25, and 26). When the met section originates a message, the subscriber name of the addressee may be specified; however, the destination code in the header must be specified. If the subscriber name is left blank, the subscriber name defaults to the logical name of the destination code. Therefore, the sender should enter the subscriber name if he wishes to relay the message through to another subscriber.

```
                  2
2  3  4  5  6  7  8  9  0  1  2  3  4  5  6  7
S  B  :  -  /  _  /  _  /  _  _  ,  _  _  _  ;
```

Figure A-4. Subscriber Field Format

d. **Security Classification**. The security classification field occupies positions 28 through 33. It is entered automatically. This field contains one of the entries in Table A-1. The security classification field format is shown in Figure A-5.

ENTRIES	MEANINGS
UN	Unclassified
ETO	Encrypt for transmission only

C	Confidential
S	Secret
CFR	Confidential formerly restricted data
SRD	Secret restricted data
C*C	Confidential cryptography (crypto)
S#C	Secret crypto

Table A-1. Security Classification Field Entries

```
          3
8   9     0    1    2    3
C   :     _    _    _    ;
```

Figure A-5. Security Classification Field Format

e. **Segment Information**. The segment information field (Figure A-6) occupies positions 34 through 42. Positions 37 and 38 indicate the message segment. Positions 40 and 41 indicate the total number of segments in the message chain. For example, "SG: 03,10;" means that this message segment is the third of 10 message segments. If the field is not specified, one segment is assumed by the receiving computer. Message segment numbers are automatically inserted in all transmitted messages.

```
                4
4   5   6   7   8   9   0   1   2
S   G   :   _   _   ,   _   _   ;
```

Figure A-6. Segment Information Field Format

f. **Date-Time Group**. The date-time-group field (Figure A-7) occupies positions 43 through 57 of the comm line. For FDC originated messages, the FDC enters the time of the last computer action or transmission. For met section originated messages, the date-time group should be left blank since the FDC inserts the time of receipt. Positions 46 and 47 indicate the day of the month (1 through 31). Positions 49 and 50 indicate the hour (00 through 23). Positions 52 and 53 indicate the minutes (00 through 59). Positions 55 and 56 indicate the seconds (00 through 59).

```
                5
3   4   5   6   7   8   9   0   1   2   3   4   5   6   7
D   T   :   _   _   ,   _   _   /   _   _   /   _   _   ;
```

Figure A-7. Date-Time-Group Field Format

g. **Message Identification Number**. This number is a unique serial ID number assigned by the computer at the FCE. This field (Figure A-8) occupies positions 58 through 65.

```
            6
8   9   0   1   2   3   4   5
I   D   :   _   _   _   _   ;
```

Figure A-8. Message Identification Number Field Format

h. **Automatic Transmission**. The automatic transmission field (Figure A-9) occupies positions 66 through 69. The initial setting of this field is left blank. If automatic transmission is used, the computer inserts the character A in position 68.

```
            6   7   8   9
            A   :   _   ;
```

Figure A-9. Automatic Transmission Field Format

i. **Digital Data Terminal**. Position 70 indicates the digital data terminal (DDT) at the FDC that is used to transmit the message. Positions 71 and 72 are not used. Figure A-10 shows the DDT field format.

```
            7
            0   1   2
            _
```

Figure A-10. Digital Data Terminal Field Format

A-3. MET MESSAGE BODY

The body of the met message is comprised of a heading and up to five data lines.

a. **Heading**. The message heading gives the message type, location of the met section, date and time group in Greenwich mean time (GMT), altitude above sea level, atmospheric pressure, and for the target acquisition (TA) message, the cloud height from surface and the mean refractive index. Figure A-11 is an example of the heading of a met message. Table A-2 identifies individual fields of the heading.

b. **Data Lines**. Each data line contains the met data for several zones, rather than each zone being transmitted by a separate line as in the standard message. Data for each zone within the data line are terminated by a comma. The data line is terminated by a semicolon.

(1) **Computer Met Message**. Each data line in the body of the computer message contains zone data for line number, wind direction and speed, and temperature and midpoint pressure. Figure A-12 shows the format for a computer met message. The symbols in the body of the computer met message are defined in Table A-3.

(2) **Fallout Met Message**. Each data line in the body of the FOMET message contains zone data for zone number and wind direction and speed. Figure A-13 shows the format for the FOMET message. The symbols in the body of the FOMET message are defined in Table A-4.

MET;CM;Q:X;POSI:xxxxxx;DTI:YY/GG.G/V;HGT:hhh;ATMS:ppp;

Figure A-11. FATDS Met Message Heading Format

FIELDS	DESCRIPTIONS
MET;	Designates message category-meteorological.
CM;	Designates message type (for this example, computer). Other message designator types are as follows: • BM - ballistic (plaintext message [PTM]). • CFL - fallout. • TA - target acquisition. • W - WMO (PTM).
K;t; (ballistic only)	Designates the types of ballistic messages as follows: • 2 - surface to air. • 3 - surface to surface.
_/_/_/_ _ _; (target acquisition only)	Identifies met station. The first five spaces are left blank. Divarty units may use DA1 or DA2 in the last three spaces. FA brigade units may use BD1 or what is designated by tactical standing operating procedure (TSOP).
Q:X;	Designates octant of the globe. The X is Octant 0, 1, 2, 3, 5, 6, 7, 8, or 9. Octant 4 is not used. Octant 9 is used when location is other than by latitude and longitude.
POSI:xxxxxx;	Designates location of station in six digits. The first three digits are used to encode the latitude and the last three to encode the longitude in degrees and tenths of degrees. When longitude is greater than 100, the hundreds digit is omitted. The location may be expressed in code.
DTI:YY/GG.G/V;	Designates date-time. The YY is the day of he month. The GG.G is the time of day in hours and tenths of an hour (24-hour clock). The V is the valid time period. **NOTE**: US Forces use 0 for valid time, since they do not predict a period of validity.
HGT:hhh;	Designates altitude of the met station above mean sea level in tens of meters.
ATMS:PPP;	Designates met station pressure to the nearest millibar. For pressures greater than 1,000 mb, thousands digit (000 to 999) is omitted. **NOTE**: This field is used for all met messages **except** the fallout met message.
CBMRI:CCC/NNN;	Designates cloud height (CCC) above the surface of the lowest cloud at the point of observation and the mean refractive index in "N" units. Cloud height is in tens of meters. If NNN is not included in the message, the spaces are left blank. **NOTE**: This field is used only for the target acquisition met message.

Table A-2. FATDS Met Message Heading Fields

(comm line)
MET;CM;Q:X;POSI:xxxxxx;DTI:YY/GG.G/V;HGT:hhh;ATMS:PPP;
LINEA:ZZ/DDD/FFF/TTT.T/PPPP,ZZ/DDD/FFF/TTT.T/PPPP,ZZ/DDD/FFF/TTT.T/PPPP;

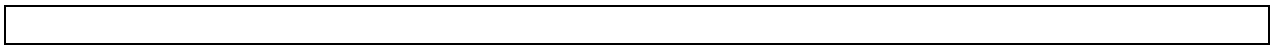


Figure A-12. FATDS Computer Met Message Format

SYMBOLS	DEFINITIONS
ZZ/	Line number (zone) for message (00 to 26)
DDD/	Zone wind direction in tens of mils (000 to 640)
FFF/	Zone wind speed in knots (000 to 300) **NOTE**: When FFF is 000, then DDD is 000.
TTT.T/	Zone mean virtual temperature to the nearest tenth of a degree Kelvin (000.0 to 500.0)
PPPP	Zone midpoint pressure in millibars (0000 to 1100)

Table A-3. FATDS Computer Met Message Body Symbols

(comm line)
MET;CFL;Q:X;POSI;xxxxx;DTI:YY/GG.G/V;HGT:hhh;
LINA:ZZ/DDD/FFF,ZZ/DDD/FFF,ZZ/DDD/FFF;

Figure A-13. FATDS Fallout Met Message Format

SYMBOLS	DEFINITIONS
ZZ/	Line designator for 2,000-meter zones (00 to 15)
DDD/	Zone wind direction in tens of mils (000 to 640)
FFF	Zone wind velocity in knots (001 to 300)

Table A-4. FATDS Fallout Met Message Body Symbols

(3) **Target Acquisition Met Message**. Each data line in the body of the TA met message contains zone data for zone number, wind direction, wind speed, temperature, and relative humidity (RH). Figure A-14 shows the format for the TA met message. The symbols in the body of the TA met message are defined in Table A-5.

A-4. PLAINTEXT MET MESSAGES

As stated before, some receiving systems may not have the formats for the ballistic met message or the WMO met message in their database. However, a ballistic met message can be transmitted to an FA unit in a plaintext message (PTM) and the WMO met message can be sent to the SWO by PTM. The comm line of the PTM is the same as the comm line of the computer, fallout, and TA met messages. The main differences are the heading and the body of the messages.

a. **Ballistic Met Message**. The heading of the ballistic met message contains the same information as the formatted messages. However, the ballistic met message is preceded by the words ** *BALLISTIC MESSAGE* **. Symbols in the heading of the PTM format ballistic met message are defined in Table A-6. The body of the PTM ballistic met message (Figure A-15) contains four data lines (LNA through LND). Each data line consists of four zones separated by commas. Symbols in the body of the PTM format bal-listic met message are defined in Table A-7.

(comm line)
MET;TA;_/_/_/__/___;Q:9;POSI:xxxxxx;DTI:YY/GG.G/V;HGT:HHH;ATMS:PPP;CMBRI:CCC/NNN;
LNA:ZZ/DDD/FFF/TTTT/UU/,ZZ/DDD/FFF/TTTT/UU/,ZZ/DDD/FFF/TTTT/UU;
LNB:ZZ/DDD/FFF/TTTT/UU/,DDD/FFF/TTTT/UU/,ZZ/DDD/FFF/TTTT/UU;

Figure A-14. FATDS Target Acquisition Met Message Format

SYMBOLS	DEFINITIONS
ZZ/	Line number code (00 to 27)
DDD/	Wind direction in tens of mils (000 to 640)
FFF/	Wind speed in knots (000 to 300)
TTTT/	Air temperature in tenths of Kelvin (000.0 to 500.0)
UU	Relative humidity as a percentage (01 to 00, where 00 is 100 percent)

Table A-5. FATDS Target Acquisition Met Message Symbols

(comm line)
SYS;PTM: ** BALLISTIC MESSAGE **
MET BM K:t Q:x POSI:xxxxxx DTI:YY/GG.G/V HGT:hhh ATMS:PPP
LNA:ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR;
LNB:ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR;
LNC:ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR;
LND:ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR,ZZ/DD/FF/TTT/RRR;

Figure A-15. Ballistic Met Message (PTM) Format

SYMBOLS	DEFINITIONS
MET	Designates message category-meteorological.
BM	Designates message type-ballistic.
K:t	Designates type of ballistic met message. The t is a 2 for type 2 (surface to air) or a 3 for type 3 (surface to surface) message.
Q:X	Designates octant of the globe. The X is octant 0, 1, 2, 3, 5, 6, 7, 8, or 9. Octant 4 is not used. Octant 9 is used when location is other than by latitude and longitude.
POSI:xxxxxx	Designates location of station is six digits. The first three digits are used to encode the latitude and the last three to encode the longitude in degrees and tenths of degrees. When longitude is greater than 100 degrees, the hundreds digit is omitted. The location may be expressed in code.
TI:YY/GG.G/V	Indicates date-time. The YY is day of the month. The GG.G is the time of day in hours and tenths of an hour (24-hour clock). The V is the valid time period. **NOTE**: US Forces use 0 for valid time, since they do not predict a period of validity.
HGT:hhh	Designates altitude of the met station above mean sea level (MSL) in tens of meters.
ATMS:PPP	Designates met station pressure to 0.1 percent of standard. If pressure is greater than 100 percent the hundreds digit is omitted.

Table A-6. FATDS Ballistic Met Message Heading Symbols

SYMBOLS	DEFINITIONS
ZZ/	Line number (zone) (00 to 15)
DD/	Ballistic wind direction in hundreds of mils (00 to 64) **NOTE**: When FF is 00, the DD is 00.
FF/	Ballistic wind speed in knots (00 to 99). (When wind speed equals or exceeds 100 knots, add 80 to the line number [ZZ].)
TTT/	Ballistic air temperature in percent of standard to the nearest 0.1 percent (000 to 999)
RRR	Ballistic air density in percent of standard to the nearest 0.1 percent (000 to 999)

Table A-7. Ballistic Met Message Body Symbols

b. **World Meteorological Organization Met Message**. The heading of the WMO met message is included in the SYS;PTM line instead of having a separate line as with other messages. The body of the message contains atmospheric data presented in the standard WMO message format, not in the data line format. The PTM format for the WMO met message is shown in Figure A-16. All of the entries for each part are not shown. For a discussion of the entries for each part, see Paragraph A-15 below. The symbols in the heading of the PTM format WMO met message are defined in Table A-8.

(comm line)
SYS;PTM: METWQ $L_aL_aL_a$GG $L_oL_oL_o$gg YYHHH PASS TO STAFF WEATHER OFFICER TTAA

(comm line)
SYS;PTM: METWQ $L_aL_aL_a$GG $L_oL_oL_o$gg YYHHH PASS TO STAFF WEATHER OFFICER TTBB

(comm line)
SYS;PTM: METWQ $L_aL_aL_a$GG $L_oL_oL_o$gg YYHHH PASS TO STAFF WEATHER OFFICER PPBB

(comm line)
SYS;PTM: METWQ $L_aL_aL_a$GG $L_oL_oL_o$gg YYHHH PASS TO STAFF WEATHER OFFICER TTCC

(comm line)
SYS;PTM: METWQ $L_aL_aL_a$GG $L_oL_oL_o$gg YYHHH PASS TO STAFF WEATHER OFFICER TTDD
PPDD

Figure A-16. WMO Met Message PTM Format

SYMBOLS	DEFINITIONS
MET	Message category-meteorological
W	Message type-WMO
Q	Octant of the globe (0 to 3 or 5 to 9)
$L_aL_aL_a$	Latitude of the station
GG	Release hour GMT (00 to 23)
$L_oL_oL_o$	Longitude of the station
gg	Release minute (GMT) (00 to 59)
YY	Date of release (GMT)
HHH	Altitude of met station in tens of meters

Table A-8. WMO Met Message Heading Symbols

Section II
Standard Met Messages

A-5. TRANSMISSION OF STANDARD MET MESSAGES

Standard met messages can be transmitted to users by radio, messenger, or any other means necessary. When radio is to be the primary means of transmission, the met section normally broadcasts to all users at the same time. Each standard met message is discussed in the following paragraphs.

A-6. COMPUTER MET MESSAGE

The computer met message is the primary met message used by artillery units. The computer met message differs from the ballistic message as follows:

- Zone structure is different.
- Zone values are not weighted.
- Atmospheric pressure is reported instead of air density.
- Weather elements are reported as zone values.

A-7. COMPUTER MET MESSAGE ENCODING

DA Form 3677-R (Computer Met Message) is used for recording purposes. A coded computer message is shown in Figure A-17. A reproducable copy of this form is at the rear of this manual.

a. **Identification Line**. The ID line is arranged in four six-digit groups. A symbolic code is used to identify and encode the data in the proper format. Thus the symbols for the ID line are METCMQ, $L_aL_aL_aL_oL_oL_o$, $YYG_oG_oG_oG$, and $hhhP_dP_dP_d$. In Figure A-18, the ID line is shown encoded.

(1) **Group 1**. Group 1 consists of METCMQ. The symbol METCM is placed at the beginning of each computer message. This symbol indicates that it is a met message and that it contains computer-type met data. The digit under the symbol Q represents the global octant in which the met section is located. For convenience in determining the geographical location of the reporting met section, the globe was divided into octants numbered 0 through 8. Table A-9 lists the octants of the globe.

NOTE: The number 4 is not used. The number 9 is used when the location is coded.

(2) **Group 2**. Group 2 consists of $L_aL_aL_aL_oL_oL_o$ or XXXXXX. These six spaces are used to specify the location to the nearest tenth of a degree. The symbol $L_aL_aL_a$ represents the latitude to the nearest tenth of a degree. The symbol $L_oL_oL_o$ represents the longitude to the nearest tenth of a degree. When the longitude is over 100°, the first digit is dropped.

(3) **Group 3**. Group 3 consists of $YYG_oG_oG_oG$. The symbol YY represents two digits for reporting the Greenwich date of the observation on which the message is based. The Greenwich date may differ from the local date, depending on the location and the hour of the day. The symbol $G_oG_oG_o$ represents three digits for reporting hours in tens, units, and tenths of hours. Appendix G contains a chart of the world map that gives the information needed to convert local standard time and date to GMT and date. The symbol G represents the duration of validity of the message in hours. US Forces always enter 0 in the space under G since the period of validity is not predicted. Other NATO forces use digits 1 through 8 in this space. A code of 9 indicates a predicted validity of 12 hours.

COMPUTER MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10s M)	MDP PRESSURE MB
METCM	Q	$L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	YY	$G_oG_oG_o$	G	hhh	$P_dP_dP_d$
METCM	**1**	**347**	**984**	**25**	**138**	**0**	**036**	**974**

ZONE HEIGHTS METERS	LINE NUMBER	ZONE VALUES			
		WIND DIRECTION (10s M)	WIND SPEED (KNOTS)	TEMPERATURE (1/10°K)	PRESSURE (MILLIBARS)
	ZZ	ddd	FFF	TTTT	PPPP
SURFACE	00	**310**	**004**	**2923**	**0974**
200	01	**250**	**011**	**2931**	**0962**
500	02	**316**	**011**	**2946**	**0932**
1000	03	**361**	**014**	**2931**	**0893**
1500	04	**371**	**011**	**2871**	**0841**
2000	05	**504**	**007**	**2826**	**0793**
2500	06	**453**	**015**	**2826**	**0745**
3000	07	**473**	**014**	**2741**	**0702**
3500	08	**521**	**014**	**2669**	**0658**
4000	09	**582**	**019**	**2632**	**0617**
4500	10	**576**	**023**	**2654**	**0578**
5000	11	**568**	**017**	**2653**	**0544**
6000	12	**570**	**017**	**2633**	**0493**
7000	13	**589**	**011**	**2648**	**0434**
8000	14	**611**	**014**	**2721**	**0383**
9000	15	**256**	**015**	**2683**	**0338**
10000	16	**395**	**018**	**2658**	**0297**
11000	17	**382**	**019**	**2608**	**0262**
12000	18	**377**	**037**	**2539**	**0229**
13000	19	**394**	**027**	**2488**	**0201**
14000	20	**438**	**020**	**2460**	**0174**
15000	21	**626**	**023**	**2386**	**0151**
16000	22	**002**	**025**	**2311**	**0131**
17000	23	**634**	**031**	**2264**	**0113**
18000	24	**074**	**038**	**2267**	**0097**
19000	25				
20000	26				

FROM **FORT SILL MET** TO **FDC 2/2 FA**	DATE AND TIME (GMT) **25 1400 NOV 91**	DATE AND TIME (LST) **25 0800 NOV 91**
MESSAGE NUMBER **1**	RECORDER **ROBERTS**	CHECKED **McADAMS**

DA FORM 3677-R, MAY 92 PREVIOUS EDITION OF THIS FORM MAY BE USED UNTIL EXHAUSTED.

Figure A-17. DA Form 3677-R

Q CODE	OCTANT LOCATION
0	North latitude-0° to 90° west longitude
1	North latitude-90° to 180° west longitide
2	North latitude-180° to 90° east longitude
3	North latitude-90° to 0° east longitude
4	Not used
5	South latitude-0° to 90° west longitude
6	South latitude-90° to 180° west longitude
7	South latitude-180° to 90° east longitude
8	South latitude-90° to 0° east longitude
9	To be used when the location of the met station is not indicated by latitude and longitude.

Table A-9. Octant of Globe Q Code

COMPUTER MET MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADOC

IDENTIFI-CATION	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10s M)	MDP PRESSURE MB
METCM	Q	$L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	YY	$G_oG_oG_o$	G	hhh	$P_dP_dP_d$
METCM	**1**	**347**	**984**	**25**	**138**	**0**	**036**	**974**

Figure A-18. Computer Met Message Identification Line

(4) **Group 4**. Group 4 consists of $hhhP_dP_dP_d$. The symbol hhh represents the met station altitude in tens of meters above mean sea level. The symbol $P_dP_dP_d$ represents the surface pressure in millibars. When the surface pressure is 1,000 mb or higher, the first digit is dropped.

(5) **Explanation**. The identification line (for transmittal) is shown in Figure A-18 and explained as follows:

(a) The METCM1 indicates a computer-type message and a station location in octant 1.

(b) The 347984 indicates station location at 34°42'N latitude and 98°24'W longitude.

(c) The 251380 indicates the date of the message is the 25th day of the month, GMT date, at 1348, and it is from a US Army artillery met section.

(d) The 036974 indicates the station altitude is 360 meters above mean sea level and the surface pressure is 974 mb.

b. **Message Body**. The remaining lines of the message (ZZdddFFF TTTTPPPP) represent surface and zone met data. The symbol ZZ represents the line number that identifies the reported met information with the appropriate atmospheric layer. The line numbers begin with 00 (surface) and are numbered consecutively through line 26. The symbol ddd represents the true direction from which the wind is blowing. The direction is reported in tens of mils. The symbol FFF represents the true wind speed in knots. The symbol TTTT represents the virtual temperature. This temperature is expressed to the nearest 0.1°K. The symbol PPPP represents the air pressure. This pressure is

expressed to the nearest millibar. The lines of the computer met message are encoded and transmitted in eight-digit groups with two groups for each line. An example of the first two lines of a computer met message is shown in Figure A-19. The lines are explained in the following paragraphs.

00310004	**29230974**
01250011	**29310962**

Figure A-19. Example Met Message Body

(1) **First Line**. The 00310004 indicates surface level, a wind direction of 3,100 mils, and a wind speed of 4 knots. The 29230974 indicates that the temperature is 292.3°K and that the pressure is 974 mb.

(2) **Second Line**. The 01250011 indicates line 1, a wind direction of 2,500 mils, and a wind speed of 11 knots. The 29310962 indicates that the temperature is 293.1°K and that line 1 pressure is 962 mb.

c. **Authentication and Dissemination Blocks**. At the bottom of the form, spaces are provided for entering the units to whom the message was sent or from whom it was received, the message number, the names of the persons who recorded and checked the message, and the date-time groups.

d. **Reverse Side**. The back of DA Form 3677-R (Figure A-20) shows a sample computer met message and explains the coding of the message. Also, the coding for octant of the globe is shown.

A-8. BALLISTIC MET MESSAGE

The standard ballistic met message provides for the common use and exchange of ballistic met data among the allied countries during joint combat operations. DA Form 3675-R, Ballistic Met Message, Figure A-21, is used for encoding the standard met message. A reproducable copy of this form is at the rear of this manual.

COMPUTER MET MESSAGE IS ENCODED AS FOLLOWS

1. The message is arranged in groups to be conveniently transmitted by radio or teletypewriter.

2. Information data: In the first five letters denote that the message is a computer message and the digit denotes the Q code of the global octant of the met station. The next group of six digits denotes the location of the met station in degrees and tenths of degrees. When 9 of the Q code is used, the six digits denote the clear or coded location of the met station. The third group of digits denotes the day of the month, time of commencement of validity in hours and tenths of hours (GMT), and duration of validity in hours from 1 to 8; code figure 9 indicates 12 hours. (Note: US Forces will always use 0, since period of validity is not predicted.) The first three digits of the fourth group denote the height of the met station (met datum plane) above sea level in multiples of 10 meters. The succeeding groups of eight digits are zone values, two groups of each line of the message.

3. The following specimen message was transmitted by radio:

METCM1 347983 081450 123903
00451025 29310903
01454027 29200892
.....

EXPLANATION:

Group 1 Computer message. Met station located in global octant 1 (N latitude, 90°-180° longitude W.)

Group 2 Center of the area of applicability of the message (station location) is 34°42'N; 98°18'W.

Group 3 8th day of the month. Valid time commences at 1430 hours GMT. Period of validity is not predicted by US units.

Group 4 Met station is 1,230 meters above MSL. The MDP pressure is 903 millibars.

Group 5 & 6 At the surface (line 00), the wind direction is 4,510 mils and the wind speed is 25 knots. The surface temperature is 293.1°K, and surface pressure is 903 millibars.

Group 7 & 8 For line 01 (0-200 meters), the zone wind direction is 4,540 mils and wind speed is 27 knots. Zone temperature is 292.0°K, and zone pressure is 892 millibars.

Q Code for Octant of Globe

0-North latitude 0-90 west longitude
1-North latitude 90-180 west longitude
2-North latitude 180-90 east longitude
3-North latitude 90-0 east longitude
4-Note used
5-South latitude 0-90 west longitude
6-South latitude 90-180 west longitude
7-South latitude 180-90 east longitude
8-South latitude 90-0 east longitude
9-Used when the location of the meteorological station is not indicated by latitude and longitude.

DA FORM 3677-R, MAY 92 PAGE 2

Figure A-20. DA Form 3677-R (Reverse)

BALLISTIC MESSAGE

For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION	TYPE MSG	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10s M)	MDP PRESSURE
METB	K	Q	$L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	YY	$G_oG_oG_o$	G	hhh	% OF STD PPP
METB									

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	BALLISTIC WINDS		BALLISTIC AIR	
		DIRECTION (100s M) dd	SPEED (KNOTS) FF	TEMPERATURE (% OF STD) TTT	DENSITY (% OF STD) ΔΔΔ
SURFACE	00	**31**	**04**	**014**	**949**
200	01	**25**	**11**	**020**	**944**
500	02	**30**	**11**	**028**	**938**
1000	03	**35**	**14**	**032**	**936**
1500	04	**36**	**11**	**030**	**938**
2000	05	**41**	**07**	**027**	**940**
3000	06	**44**	**12**	**025**	**942**
4000	07	**51**	**10**	**014**	**947**
5000	08	**54**	**12**	**021**	**946**
6000	09	**54**	**13**	**030**	**947**
8000	10	**57**	**11**	**030**	**934**
10000	11				
12000	12				
14000	13				
16000	14				
18000	15				

REMARKS

DELIVERED TO: **FDC 2/2 FA** RECEIVED FROM : **FORT SILL MET**	DATE (GMT) **1400**	TIME (LST) **0800**
MESSAGE NUMBER **1**	DATE **25 NOV 91**	
RECORDER **ROBERTS**	CHECKED **McADAMS**	

DA FORM 3675-R, MAY 92 PREVIOUS EDITION OF THIS FORM MAY BE USED UNTIL EXHAUSTED.

Figure A-21. DA Form 3675-R (Ballistic Met Message)

A-9. BALLISTIC MET MESSAGE ENCODING

A symbolic code is used to conveniently encode the ballistic met message data in proper format. The data are arranged in six-digit groups for transmitting the message.

a. **Identification Line**. The first four six-digit groups pertain to the ID line of the ballistic met message. The symbols are not trans-mitted; they are only used by the encoder to put the information in proper format and sequence. Detailed explanations of the symbols and the coding procedures for the ID line are discussed in the following paragraphs. Figure A-22 shows an encoded identification line.

(1) **Group 1**. Group 1 consists of METBKQ. The symbol METB is placed at the beginning of each ballistic met message. These letters indicate that it is a met message and that it includes ballistic met data. Either a 2 or a 3, depending on the type of ballistic met message, is entered for the symbol K. The type 2 message is prepared for surface-to-air trajectories. The type 3 message is prepared for surface-to-surface trajectories. The digit under the symbol Q represents the code for the global octant in which the met section is located. For convenience in determining the geographical location of the reporting met station, the globe was divided into octants numbered 0 through 8.

NOTE: The number 4 is not used. The digit 9 is used when the location is coded.

(2) **Group 2**. Group 2 consists of $L_aL_aL_aL_oL_oL_o$ or XXXXXX. The symbol $L_aL_aL_a$ represents the latitude to the nearest tenth of a degree. The symbol $L_oL_oL_o$ represents the longitude to the nearest tenth of a degree. When the longitude is over 100°, the first digit is dropped.

(3) **Group 3**. Group 3 consists of $YYG_oG_oG_oG$. The symbol YY represents two digits for reporting the Greenwich date of the observation on which the message is based. The Greenwich date may differ from the local date, depending on the location and the hour. The symbol $G_oG_oG_o$ represents three spaces for reporting the time of commencement of the validity of the message in hours and tenths of hours. Local standard time must be corrected to reflect GMT in this block. This correction can be made by referring to the world map in Appendix G. The symbol G represents the duration of validity of the met message in hours from 1 to 8. The code numeral 9 indicates a period of validity of 12 hours. US Forces always enter a 0 in the space under G since the period of validity is not predicted.

BALLISTIC MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFI-CATION	TYPE MSG	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10s M)	MDP PRESSURE % OF STD
METB	K	Q	$L_aL_aL_a$ or xxx	$L_oL_oL_o$ or xxx	YY	$G_oG_oG_o$	G	hhh	PPP
METB	**3**	**1**	**347**	**984**	**25**	**38**	**0**	**036**	**961**
		BALLISTIC WINDS				BALLISTIC AIR			

Figure A-22. Ballistic Met Message Identification Line

(4) **Group 4**. Group 4 consists of hhhPPP. The symbol hhh represents the three digits indicating the altitude of the met station. The three spaces under hhh are used to express the altitude in tens of meters above mean sea level. The symbol PPP represents the three digits indicating the atmospheric pressure at the met station to the nearest 0.1 percent of the ICAO standard. When pressure is 100 percent or over, the first digit is dropped.

(5) **Explanation**. The identification line is shown in Figure A-22 and explained as follows:

(a) The METB31 indicates a ballistic message type 3, surface to surface, and a station location in octant 1.

(b) The 347984 indicates a station location at 34° 42'N latitude and 98° 24'W longitude.

(c) The 251380 indicates the date of the message is the 25th day of the month, GMT date, at 1348, and it is from a US Army met section.

(d) The 036961 indicates the station altitude is 360 meters above mean sea level and the surface pressure is 96.1 percent of standard.

b. **Message Body**. The columns and lines in the body of the message (Figure A-21) are used for encoding the ballistic data for each line of the ballistic message. The first column is a list of the standard zone heights in meters. The zone height data are not transmitted. The second column lists the line numbers identifying each artillery zone of the atmosphere. The remaining four columns are used for encoding the ballistic met data pertaining to each line. Each line is transmitted in two six-digit groups representing the line number and the ballistic data in each standard zone. For example, the symbols for a line are ZZddFF and TTT ΔΔΔ.

(1) **Group 1**. The symbol ZZ indicates 00 for surface, 01 for line 1, 02 for line 2, and so on. The symbol dd represents the two digits indicating ballistic wind direction in hundreds of mils. The symbol FF represents the two digits indicating ballistic wind speed in knots.

(2) **Group 2**. The symbol TTT represents the three digits indicating ballistic temperature in percent of standard to the nearest tenth of a percent. For temperatures above 100 percent, the first digit is dropped. The symbol ΔΔΔ represents the three digits indicating ballistic density in percent of standard to the nearest tenth of a percent. For densities over 100 percent, the first digit is dropped.

(3) **Explanation**. The first line, (003104 and 014949), of the met message (Figure A-21) indicates the following:

- 00-Surface information follows.
- 31-Surface wind direction is 3,100 mils.
- 04-Surface wind speed is 4 knots.
- 014-Surface temperature is 101.4 percent of standard.
- 949-Surface density is 94.9 percent of standard.

c. **Remarks Section**. Below the ballistic data (Figure A-21), a space is provided for any remarks deemed appropriate, such as a comment on any unusual data in the message.

d. **Winds Exceeding 100 Knots**. Anytime a ballistic wind exceeds 100 knots, 100 is subtracted from the speed (for example, 105 - 100 = 05). The result (05) is entered in the winds speed column of the ballistic message. To permit easy identification of a line number in which the ballistic wind exceeds 100 knots, 80 is added to that line number (for example, line 05 + 80 = 85).

e. **Authentication and Dissemination Blocks**. At the bottom of the form, spaces are provided for entering the units to whom the message was sent or from whom it was received, the message number, the names of the persons who recorded and checked the message, and the date-time groups.

f. **Reverse Side**. The back of the form (Figure A-23) shows a sample ballistic met message and explains the encoding. Also, the information for coding the octant of the globe is shown.

THE BALLISTIC MET MESSAGE IS ENCODED AS FOLLOWS

1. The ballistic met message is arranged to be conveniently transmitted by radio or teletypewriter in groups of six digits or letters.

2. Information data: The first four letters denote that the message is a ballistic met message. The next letter denotes the type of ballistic met message-2 for surface-to-air trajectories or 3 for surface-to-surface trajectories. The sixth digit is the Q code of the global octant location of the met station, and the following six digits denote the location of the met station in degrees and tenths of degrees. When 9 of the Q code is used, the following six digits denote the clear or coded location of the met station. The third group of six digits denotes the day of the observation, time of commencement of validity in hours and tenths of hours (GMT), and duration of validity in hours from 1 to 8; code figure 9 indicates 12 hours. (Note: US Forces will always use 0, since period of validity is not predicted.) The fourth group of six digits denotes the station height and the station pressure expressed in percent of standard ICAO pressure. All succeeding groups of six are ballistic data.

3. The following specimen message was transmitted by radio:

METB31 625468 290250 025001
000701 860163
015510 863162
.....

EXPLANATION:

Group 1 Met message for surface-to-surface fire, type 3 message. The met station located in global octant 1.

Group 2 Center of the area of applicability of the message (station location) 62°30' N; 146°48' W.

Group 3 29th day of the month. Valid time commences at 0230 hours GMT. Period of validity is not predicted by US units.

Group 4 Met station is 250 meters above mean sea level. Station pressure is 100.1% of standard ICAO pressure.

Group 5 For line 00 (surface), ballistic wind direction is 700 mils and wind speed is 1 knot.

Group 6 For line 00, the ballistic temperature is 86.0% of standard and the ballistic density is 116.3% of standard.

Group 7 For line 01 (0-200 meters), ballistic wind direction is 5,500 mils and wind speed is 10 knots.

Group 8 For line 01, the ballistic temperature is 86.3% of standard and ballistic density is 116.2% of standard.

Q Code for Octant of Globe

0-North latitude 0-90 west longitude
1-North latitude 90-180 west longitude
2-North latitude 180-90 east longitude
3-North latitude 90-0 east longitude
4-Note used
5-South latitude 0-90 west longitude
6-South latitude 90-180 west longitude
7-South latitude 180-90 east longitude
8-South latitude 90-0 east longitude
9-Used when the location of the meteorological station is not indicated by latitude and longitude.

DA FORM 3675-R, MAY 92 PAGE 2

Figure A-23. DA Form 3675-R (Reverse)

A-10. TARGET ACQUISITION MET MESSAGE

The TA met message defines a format for use with unmanned aerial vehicles (UAVs), remotely piloted vehicles (RPVs), drones, and weapons-locating radars (WLRs). The TA met message standardizes the number of information digits in the message and their meanings. This standardization makes it possible for all armed forces to understand and use TA met message information issued by any service of any armed forces.

A-11. TARGET ACQUISITION MET MESSAGE ENCODING

The sequence and number of symbols for a TA met message are in Table A-10.

a. **Group 1**. Group 1 consists of METTAQ. The symbol METTA indicates that this is a TA met message. The symbol Q represents the octant of the globe.

b. **Group 2**. Group 2 consists of $L_aL_aL_aL_oL_oL_o$ or XXXXXX. The symbol $L_aL_aL_a$ represents the latitude to the nearest tenth of a degree. The symbol $L_oL_oL_o$ represents the longitude to the nearest tenth of a degree. When the longitude is over 100, the first digit is dropped.

c. **Group 3**. Group 3 consists of $YYG_oG_oG_oG$. The symbol YY represents the day of the month (GMT) of the commencement of the period of validity of the message. The symbol $G_oG_oG_o$ represents the time of commencement of the period of validity of the message. Time is recorded in tens, units, and tenths of an hour (GMT). The symbol G represents the duration of the period of validity in hours from 1 to 8. Code figure 9 indicates 12 hours. US Forces use 0 since the period of validity is not predicted.

d. **Group 4**. Group 4 consists of $hhhP_dP_dP_d$. The symbol hhh represents the height of the met section above mean sea level in tens of meters. The symbol $P_dP_dP_d$ represents the pressure at the met section location expressed in hundreds, tens, and units of millibars. When the value of the air pressure is 1,000 mb or more, the first digit is omitted.

GROUPS	SYMBOLS
1	**METTAQ**
2	**$L_aL_aL_aL_oL_oL_o$ or XXXXXX**
3	**$YYG_oG_oG_oG$**
4	**hhh $P_dP_dP_d$**
5	**CCC NNN**
6	**$Z_tZ_t$ddd FFF**
7	**ttttUU**
8	**99999**

NOTES:
1. Group 6 and 7 are repeated for each zone number of the message. Only those zones of the message that are required by the recipient need be used.
2. If any data are not available, the missing data are indicated with a slash (/) for each missing digit. This note applies also to optional groups such as NNN in group 5.

Table A-10. TA Met Message Groups

e. **Group 5**. Group 5 consists of CCCNNN. The symbol CCC represents the height of the base of the lowest cloud at the point of observation. It is given in tens of meters according to the cloud code in Table A-11. The symbol NNN represents mean refractive index

at the surface in N units. If NNN is not to be included in the message, these missing data will be indicated by three slashes (///).

f. **Group 6**. Group 6 consists of $Z_tZ_t$dddFFF. The symbol Z_tZ_t represents the zone number code. Table A-12 lists zone number codes. The symbol ddd represents the mean wind direction for the zone given in thousands, hundreds, and tens of mils. For zone number 00, the value is the wind direction at the met section location. The symbol FFF represents the mean wind speed of the zone in hundreds, tens, and units of knots. For zone number 00, the value is the wind speed at surface.

g. **Group 7**. This group consists of ttttUU. The symbol tttt represents the mean air temperature of the zone in hundreds, tens, units, and tenths of a degree Kelvin. For zone number 00, the value is the air temperature at surface. The symbol UU represents the mean RH expressed as a percentage in tens and units. A mean RH of 100 percent is denoted by 00.

h. **Group 8**. Group 8 consists of 99999. This group is a message terminator. It is used only when the message is transmitted by telegraphic means.

CODE	DESCRIPTION
000	Indicates sky obscured by fog.
001-160	Indicates visual estimate of base of lowest cloud, in tens of meters, below 1,600 meters.
166	Indicates visual estimate of base of lowest cloud above 1,600 meters.
199	Indicates clear sky.
301-460	Indicates base of lowest cloud observed by searchlight or laser. Subtract 300 to obtain base of lowest cloud observed by searchlight or laser, in tens of meters, if below 1,600 meters.
466	Indicates base of lowest cloud observed by searchlight or laser above 1,600 meters.
477	Indicates searchlight or laser observation unreliable.
499	Indicates no cloud detected by searchlight or laser.
501-660	Indicates height at which a balloon was lost in cloud. Subtract 500 to obtain height at which a balloon was lost in cloud, in tens of meters, if below 1,600 meters.
666	Indicates balloon lost above 1,600 meters.
677	Indicates balloon observation unreliable.
NOTE: Each service uses that portion of the code appropriate to its own procedures.	

Table A-11. Cloud Code

Z_tZ_t	HEIGHT OF MIDPOINT OF ZONE ABOVE MDP (METERS)	HEIGHT ABOVE MDP OF ZONE (METERS)	
		BASE	TOP
00	0	-	-
01	25	0	50
02	75	50	100
03	150	100	200
04	250	200	300
05	350	300	400
06	450	400	500
07	550	500	600
08	650	600	700
09	750	700	800
10	850	800	900
11	950	900	1000
12	1050	1000	1100
13	1150	1100	1200
14	1250	1200	1300
15	1350	1300	1400
16	1450	1400	1500
17	1550	1500	1600
18	1650	1600	1700
19	1750	1700	1800
20	1850	1800	1900
21	1950	1900	2000
22	2050	2000	2100
23	2150	2100	2200
24	2250	2200	2300
25	2350	2300	2400
26	2450	2400	2500
27	2550	2500	2600

Table A-12. Zone Number Code

A-12. SOUND RANGING MET MESSAGE

Sound ranging met messages are used by sound ranging platoons to determine the location of sound sources. Locating sound sources requires hourly updates concerning the atmosphere through which the sound waves pass. Required data are the effective temperature characteristics of the atmosphere between the sound source and the sound base and the effect of the wind on the rate and direction of travel of the sound wave. Sound ranging platoons can provide the required data themselves on an hourly basis. Met sections can provide the data only when soundings are made as scheduled, but normally not hourly. Also, met sections may be positioned a great distance from a sound ranging platoon. Since the US Army no longer has sound ranging platoons in the force structure, met sections will probably have a requirement for sound ranging met messages only when supporting allied operations.

A-13. SOUND RANGING MET MESSAGE ENCODING

When used, the sound ranging met message is provided in the format shown in Figure A-24. The parts of the sound ranging met message are discussed in the following paragraphs.

METSR Q $L_aL_aL_aL_oL_oL_o$ **dd tttt TTT DDD SS**

Figure A-24. Sound Ranging Met Message Format

a. **METSR**. The symbol METSR indicates that this is a sound ranging met message.

b. **Q**. The symbol Q represents the octant of the globe in which the met station is located.

c. **$L_aL_aL_a$**. The symbol $L_aL_aL_a$ represents the latitude of the met station to the nearest tenth of a degree.

d. **$L_oL_oL_o$**. The symbol $L_oL_oL_o$ represents the longitude of the met station to the nearest tenth of a degree.

e. **dd**. The symbol dd represents the day of the month (GMT) of the sound ranging met message.

f. **tttt**. The symbol tttt represents the time message validity begins.

g. **TTT**. The symbol TTT represents the effective (sonic) temperature to the nearest tenth of a degree Celsius.

h. **DDD**. The symbol DDD represents the effective wind direction in mils.

i. **SS**. The symbol SS represents the effective wind speed in knots.

A-14. WORLD METEOROLOGICAL ORGANIZATION MET MESSAGE

The WMO met message provides high-altitude sounding data. The met section automatically provides the message in the WMO format. Paragraph A-15 explains the encoded format and the standard automated message (WMO format) produced by artillery met sections to support the SWO.

A-15. WORLD METEOROLOGICAL ORGANIZATION MET MESSAGE ENCODING

The automated WMO message consists of a heading and a message body. The encoded format conforms to the WMO format for worldwide transmission of met data. The body of the message is in six parts; each part consists of groups of five digits.

- Part A (TTAA) - Mandatory level data below 100 mb.
- Part B (TTBB) - Significant level data below 100 mb (temperature and dew point).
- Part B (PPBB) - Significant level data below 100 mb (wind direction and speed).
- Part C (TTCC) - Mandatory level data above 100 mb.
- Part D (TTDD) - Significant level data above 100 mb (temperature and dew point).
- Part D (PPDD) - Significant level data above 100 mb (wind direction and speed).

a. **Heading**. The heading of the WMO met message is an identification line encoded in the format shown in Figure A-25. The parts of the met message identification line are discussed in the following paragraphs.

METWQ$L_aL_aL_a$GG$L_oL_oL_o$ggYYhhh

Figure A-25. WMO Met Message Heading

(1) **METW**. The symbol METW identifies the met message as being a met message in WMO format.

(2) **Q**. The symbol Q represents the octant of the globe. The octant identifies the part of the globe in which the met section is located.

(3) **$L_aL_aL_a$**. The symbol $L_aL_aL_a$ identifies the latitude of the met station location.

(4) **GG**. The symbol GG identifies the release hour (GMT) of the sounding.

(5) **$L_oL_oL_o$**. The symbol $L_oL_oL_o$ identifies the longitude of the met station location.

(6) **gg**. The symbol gg identifies the release time to the nearest minute (GMT).

(7) **YY**. The symbol YY represents the date of release (GMT).

(8) **hhh**. The symbol hhh represents met station altitude in tens of meters.

b. **Part A (TTAA) - Mandatory Level Data**. Part A consists of mandatory level temperature, dew point (DP), and wind direction and speed below 100 mb. The format of Part A data is in Figure A-26.

(1) **Section 1**. Section 1 of Part A contains individual position identification data. Individual entries for Section 1 of Part A are discussed in the following paragraphs.

(a) The symbol TTAA identifies the data as Part A (mandatory levels).

(b) The symbol YY represents the date of the flight (GMT).

NOTE: If wind speeds are recorded in knots, then 50 is added to the date. For example, 15 May is encoded 65. If wind speeds are recorded in meters per second, then the date is recorded in the normal manner.

(c) The symbol GG represents the time of observation to the nearest whole hour (GMT).

(d) The symbol Id represents the hundreds' digit of the last millibar level that winds are available. See Table A-13 lists the codes for last millibar level that winds are available.

IDENTIFICATION-POSITION (Section 1)					
TTAA YYGGId		IIiii			
SURFACE-STANDARD ISOBERIC LEVELS (Section 2)					
$99P_oP_oP_o$	$T_oT_oT_{ao}D_oD_o$	$d_od_of_of_of_o$	00hhh TTT_aDD	ddfff 92hhh TTT_aDD	ddfff
85hhh	TTT_aDD	ddfff	70hhh TTT_aDD	ddfff 50hhh TTT_aDD	ddfff
40hhh	TTT_aDD	ddfff	30hhh TTT_aDD	ddfff 25hhh TTT_aDD	ddfff
20hhh	TTT_aDD	ddfff	15hhh TTT_aDD	ddfff 10hhh TTT_aDD	ddfff
TROPOPAUSE DATA (Section 3)					
$88P_tP_tP_t$	$T_tT_tT_{at}DtD_td_td_tf_tf_tf_t$				
MAXIMUM WIND DATA (Section 4)					
77 or 66	$P_mP_mP_m$	$d_md_mf_mf_mf_m$	$4v_bv_bv_av_a$		

Figure A-26. Format for Part A (TTAA) of WMO Met Message

(e) The symbol IIiii is a USAF location code. The II identifies the country or geographic area. The iii identifies individual stations within the country or geographic area.

(2) **Section 2**. Surface data and standard isobaric surfaces data comprise Section 2 of Part A. Entries for Section 2 are discussed in the following paragraphs.

(a) The number 99 is the surface indicator.

(b) The symbol $P_oP_oP_o$ represents the surface pressure. If the surface pressure is over 1,000 mb, drop the thousands' digit.

(c) The symbol $T_oT_oT_{ao}$ represents the temperature to the tenths of a degree Celsius. The last digit (T_{ao}) indicates if it is a positive or negative temperature value. Table A-14 lists temperature codes.

(d) The symbol D_oD_o represents the DP depression. Table A-15 lists DP depression codes. DP depressions of 0.0 to 4.9 are encoded as 00 to 49. DP depressions from 5.0 to 5.5 are encoded as 50. DP depressions 5.5 and above are rounded off to the nearest whole degree and 50 is added to the result. (For example, DP depression 15.8 is encoded 16 + 50 = 66.)

(e) The symbol $d_od_of_of_of_o$ represents wind direction and speed. Wind direction is rounded to the nearest 5°. The last digit of the wind direction is added to the first digit of the wind speed when wind speed exceeds 99 knots. (For example, a wind direction of 293 and a wind speed of 45 knots are encoded as 29545. A wind direction of 115 and a wind speed of 126 knots are encoded as 11626.)

(f) The symbol hhh represents height in geopotential meters. This is a mandatory data entry for mandatory pressure levels. Table A-16 lists mandatory pressure levels.

CODE FIGURE	WIND GROUP REPORTED UP TO AND INCLUDING THE FOLLOWING STANDARD ISOBARIC SURFACES:	
	PART A	PART C
1	100 OR 15 mb	10 mb
2	200 or 250 mb	20 mb
3	300 mb	30 mb
4	400 mb	.....
5	500 mb	50 mb
6	.....	.....
7	700 mb	70 mb
8	850 mb	.....
9	.....	.....
0	1,000 mb	.....
/	No wind groups reported for any of the standard isobaric surfaces	No wind groups reported for any of the standard isobaric surfaces

Table A-13. Codes for Last Millibar Level That Winds are Available

POSITIVE TEMPERATURE TENTHS VALUE	CODE FIGURE	NEGATIVE TEMPERATURE TENTHS VALUE	CODE FIGURE
.0	0	.0	1
.1	0	.1	1
.2	2	.2	3
.3	2	.3	3
.4	4	.4	5
.5	4	.5	5
.6	6	.6	7
.7	6	.7	7
.8	8	.8	9
.9	8	.9	9

Table A-14. Temperature Tenths Value Code

CODE FIGURE	DEPRESSION OF THE DEW POINT IN DEGREES CELSIUS	CODE FIGURE	DEPRESSION OF THE DEW POINT IN DEGREES CELSIUS
00	0.0	40	4.0
01	0.1	41	4.1
02	0.2	42	4.2
03	0.3	43	4.3
04	0.4	44	4.4
05	0.5	45	4.5
06	0.6	46	4.6
07	0.7	47	4.7
08	0.8	48	4.8
09	0.9	49	4.9
10	1.0	50	5
11	1.1	51	NOT USED
12	1.2	52	
13	1.3	53	
14	1.4	54	
15	1.5	55	
16	1.6	56	6
17	1.7	57	7
18	1.8	58	8
19	1.9	59	9
20	2.0	60	10
21	2.1	61	11
22	2.2	-	-
23	2.3	70	20
24	2.4	71	21
25	2.5	-	-
26	2.6	80	30
27	2.7	81	31
28	2.8	-	-
29	2.9	89	39
30	3.0	90	40
31	3.1	91	41
32	3.2	-	-
33	3.3	98	48
34	3.4	99	49 or more
35	3.5		
36	3.6		
37	3.7		
38	3.8		
39	3.9		

Table A-15. Dew Point Depression Code

LEVEL	MILLIBARS
00	1,000
92	925
85	850
70	700
50	500
40	400
30	300
20	200
15	150
10	100

Table A-16. Mandatory Pressure Levels

NOTES:
1. Geopotential heights are reported in whole geopotential meters for surface up to 500 mb. Geopotential heights are reported in tens of geopotential meters for heights at the 500 mb level and above. Geopotential heights below mean sea level are coded by adding 500 to the absolute value. (For example, -239 is encoded as 739 [500+239]).

2. Sometimes the surface pressure is lower than 1,000 mb, 850 mb, and so on. In this case, the 1,000 mb level is reported with slashes (///) after the height entry. Figure A-27 shows an example of this reporting.

(surface)	**99 982 1065032001**
(1,000-mb level)	**00 612 ////////////////**

Figure A-27. Surface Pressure Reporting

(g) The symbol TTTa represents the surface temperature. This is a mandatory data entry for standard isobaric surfaces.

(h) The symbol DD represents the DP depression. This is a mandatory data entry for standard isobaric surfaces.

(i) The symbol ddfff represents the wind direction and speed. This is a mandatory data entry for standard isobaric surfaces.

(3) **Section 3**. Tropopause data entries are in Section 3 of Part A. These entries are discussed in the following paragraphs.

(a) The number 88 is the tropopause data indicator.

NOTE: If tropopause data are missing, the missing data are reported encoded as 88999.

(b) The symbol $P_tP_tP_t$ represents the pressure of the tropopause.

(c) The symbol $T_tT_tT_{at}$ represents the temperature at the tropopause.

(d) The symbol D_tD_t represents the DP depression at the tropopause.

(e) The symbol $d_td_tf_tf_tf_t$ represents the wind direction and speed at the tropopause.

(4) **Section 4**. Maximum wind data entries are in Section 4 of Part A. These entries are discussed in the following paragraphs.

(a) The number 66 or 77 is the maximum wind indicator. A 66 maximum wind indicator indicates the greatest wind speed observed throughout the sounding and occurring at the terminating level of sounding. A 77 maximum wind indicator indicates the level of maximum wind speed occurring within the sounding. Maximum winds must be above the 500-mb level and over 60 knots in speed to be reported. When no maximum wind data is observed, 77999 shall be reported for Section 4.

(b) The symbol $P_mP_mP_m$ represents the pressure at wind data.

(c) The symbol $d_md_mf_mf_mf_m$ represents the maximum wind direction and speed. Wind direction is encoded to the nearest 5°. The rounded digit is added to the hundreds digit of the speed. (For example, 30160 is 300° at 160 knots.)

(d) The symbol $4v_bv_bv_av_a$ represents the vertical wind shear data. These values are derived by using analytical geometry and are not easily checked in the field. The data reported with this entry are as follows:

- 4 - Vertical wind shear data indicator.

- v_bv_b - Value of vector difference between maximum wind speed and the wind blowing at 3,000 feet below the level of the maximum winds, in knots.

- v_av_a - Value of the vector difference between the maximum wind speed and the wind blowing at 3,000 feet above the level of the maximum winds, in knots.

c. **Part B (TTBB) - Significant Data (Temperature and Dew Point) below 100 Millibars**. The format for Part B (TTBB) is shown in Figure A-28.

(1) **Section 1**. Section 1 of Part B contains position identification data. The data entries are discussed in the following paragraphs.

(a) The symbol TTBB is the Part B significant levels indicator. TT means sounding was made by a land-based station. UU means the sounding was made by a ship-based station.

(b) The symbol YY represents the date (GMT).

(c) The symbol GG represents the time of observation to the nearest whole hour (GMT).

(d) The symbol / represents the last level at which wind data were obtained.

(e) The symbol IIiii is a USAF identification code. The II identifies the country or geographic area. The iii identifies individual stations within the country or geographic area.

(2) **Section 5**. Section 5 of Part B (TTBB) is comprised of surface data and significant levels of temperature and DP. The surface data entries and the significant level data entries are discussed below.

(a) The symbol 00 is a surface indicator.

(b) The symbol $P_oP_oP_o$ represents the surface pressure.

IDENTIFICATION-POSITION (Section 1)							
TTBB	YYGG/	IIiii					
SIGNIFICANT LEVELS WITH RESPECT TO TEMPERATURE AND/OR HUMIDITY (Section 5)							
$00P_oP_oP_o$	$T_oT_oT_{ao}D_oD_o$	11PPP	TTT_aDD	22PPP	TTT_aDD	33PPP	TTT_aDD
44PPP	TTT_aDD	55...ETC.					
DATA ON SEA-SURFACE TEMPERATURE AND SOUNDING SYSTEM (Section 7)							
31313	$s_nr_ar_as_as_a$	8GGgg	$(9s_nT_wT_wT_w)$				
CLOUD DATA SYMBOLIC LETTERS AND DEFINITIONS (Section 8)							
41414	$N_hC_LhC_MC_H$						
CODE GROUPS TO BE DEVELOPED REGIONALLY (Section 9)							
51515	$101A_{df}A_{df}$						

Figure A-28. Format for Part B (TTBB) of WMO Met Message

(c) The symbol $T_oT_oT_{ao}$ represents the surface temperature.

(d) The symbol D_oD_o represents the surface DP depression.

(e) The symbol 11 and symbols continuing on in multiples of 11 are level indicators.

(f) The symbol PPP represents pressure.

(g) The symbol TTT_a represents temperature.

(h) The symbol DD represents DP depression.

(3) **Section 7**. Section 7 of Part B (TTBB) contains data on sea-surface temperature and sounding system used. The 31313 is the section indicator.

(a) The symbol S_r represents solar and infrared radiation correction.

(b) The symbol R_aR_a is the radiosonde/sounding system used.

(c) The symbol S_aS_a is the tracking technique/status of the system used.

(d) The symbol 8 is the indicator for time.

(e) The symbol Gg_{gg} represents time of observation, in hours and minutes.

(f) The 9 is the indicator for the sign of data, relative humidity, and sea-surface temperature.

(g) The symbol S_n represents the sign of data and relative humidity indicator.

(h) The symbol $T_wT_wT_w$ is the sea-surface temperature reported in tenths of a degree Celsius.

(4) **Section 8**. Section 8 of Part B (TTBB) contains cloud code information. 41414 is the section indicator. The codes can be found in Appendix B of this manual.

(a) The symbol N_h is the amount of C_L present or, if no C_L is present, the amount of all the C_M cloud present.

(b) The symbol C_L represents cloud classes stratocumulus, stratus, cumulus, and cumulonimbus.

(c) The symbol h represents the height above surface of the base of the lowest cloud seen.

(d) The symbol C_M represents cloud classes altocumulus, altostratus, and nimbostratus.

(e) The symbol C_H represents cloud classes cirrus, cirrocumulus, and cirrostratus.

(5) **Section 9**. Section 9 of Part B (TTBB) contains additional codes developed regionally.

(a) The 51515 is the section indicator.

(b) The symbol $A_{df}A_{df}$ represents the form of the additional data reported.

d. **Part B (PPBB) - Significant Data (Wind Direction and Speed) below l00 Millibars**. The format for Part B (PPBB) is shown in Figure A-29.

(1) **Section 1**. Section 1 of Part B (PPBB) contains position identification data. Data entries are discussed in the following paragraphs.

(a) The symbol PPBB is the Part B (winds data) below 100 mb.)

IDENTIFICATION-POSITION (Section 1)

PPBB	YYGGa4	Iliii

FIXED REGIONAL LEVELS AND SIGNIFICANT LEVELS (Section 4)

$9t_nu_1u_2u_3$	ddfff	ddfff	ddfff
.....			
$9t_nu_1u_2u_3$	ddfff	ddfff	ddfff

Figure A-29. Format for Part B (PPBB) of WMO Met Messages

(b) The symbol YY represents the date (GMT).

(c) The symbol GG represents the time of observation to the nearest whole hour (GMT).

(d) The symbol a_4 represents the type of instrument used in the observation.

(e) The symbol IIiii is a USAF location code. The II identifies the country or geographic area. The iii identifies individual stations within the country or geographic area.

(2) **Section 4**. Section 4 of Part B (PPBB) contains fixed regional levels data. The data entries are discussed in the following paragraphs. Fixed regional level data for Part B are in Table A-17. Heights indicated are above mean sea level.

(a) In the symbol $9t_nu_1u_2u_3$, the 9 is a height indicator, and t_n is the 10,000-foot indicator. The u_1 is the first wind level, u_2 is the second wind level, and u_3 is the third wind level. (For example, 90012 indicates surface level, 1,000-foot level, and 2,000-foot level. If surface level were over 1,000 feet above sea level, the indicator would be 90023. The 9205/ indicates 20,000-foot level and 25,000-foot level.)

(b) The symbol ddfff represents wind direction and speed. Wind direction is given to the nearest 10°. Winds are reported to the nearest 5° by adding 500 to wind speed.

FEET	METERS
1,000	300
2,000	600
3,000	900
4,000	1,200
6,000	1,800
7,000	2,100
8,000	2,400
9,000	2,700
12,000	3,600
14,000	4,200
16,000	4,800
20,000	6,000
25,000	7,500
30,000	9,000
35,000	10,500
50,000	15,000

Table A-17. Fixed Regional Levels

e. **Part C (TTCC) - Mandatory Level Temperature, Dew Point, and Wind Data Above 100 Millibars**. The format for Part C (TTCC) is shown in Figure A-30. Identification of individual entries is the same for Part C (TTCC) as for Part A (TTAA). This section is omitted if the balloon bursts between 100 and 70 mb. However, in this case, TTDD and PPDD must be transmitted so that the user can determine what data are available between 100 and 70 mb.

f. **Part D (TTDD) - Significant Level (Temperature and Dew Point) Above 100 Millibars**. The format for Part D (TTDD) is shown in Figure A-31. Identification of individual entries is the same for Part D (TTDD) as for Part B (TTBB).

g. **Part D (PPDD) - Significant Data (Wind Direction and Speed) Above 100 Millibars**. The format for Part D (PPDD) is shown in Figure A-32. Identification of individual entries is the same for Part D (PPDD) as for Part B (PPBB). Fixed regional level data for Part D are included in Table A-18. Altitudes are above mean sea level.

A-16. FALLOUT MET MESSAGES

The FOMET message contains only wind data recorded at 2,000-meter intervals from the surface to 30,000 meters. These data are used by NBC personnel mainly at division and corps levels to develop the downwind messages that predict fallout patterms.

IDENTIFICATION-POSITION (Section 1)			
TTCC	YYGGId	IIiii	
STANDARD ISOBARIC LEVELS (Section 2)			
70hhh TTT_aDD	ddfff 50hhh TTT_aDD	ddfff 30hhh TTT_aDD	ddfff
TROPOPAUSE DATA (Section 3)			
$88P_tP_tP_t$	$T_tT_tT_{at}D_tD_t$	$d_td_tf_tf_tf_t$	
MAXIMUM WIND DATA (Section 4)			
77 or 66	$P_mP_mP_m$	$d_md_mf_mf_mf_m$	$4v_bv_bv_av_a$

Figure A-30. Format of Part C (TTCC) of WMO Met Message

IDENTIFICATION-POSITION (Section 1)			
TTDD YYGG/	IIiii		
SIGNIFICANT LEVELS WITH RESPECT TO TEMPERATURE AND/OR HUMIDITY (Section 5)			
11PPP TTT_aDD	22PPP TTT_aDD	33PPP TTT_aDD	44PPP TTT_aDD
55...ETC.			

Figure A-31. Format for Part D (TTDD) of WMO Met Message

IDENTIFICATION-POSITION (Section 1)		
PPDD YYGGa4	IIiii	
FIXED REGIONAL LEVELS AND SIGNIFICANT LEVELS		
9 or 1	$t_au_1u_2u_3$	ddfff ddfff ddfff
.....		
9 or 1	$t_au_1u_2u_3$	ddfff ddfff ddfff

Figure A-32. Format for Part D (PPDD) of WMO Met Message

FEET	METERS
70,000	21,000
90,000	27,000
100,000	30,000
110,000	33,000
140,000	42,000
and for every 10,000-foot level upward	and for every 3,000-meter level upward

Table A-18. Fixed Regional Level Data

A-17. ENCODING FALLOUT MET MESSAGES

Met data for fallout predictions are recorded on DA Form 3676-R, Fallout Met Message. Figure A-33 shows an encoded fallout message. A reproducable copy of this form is at the rear of this manual. The following paragraphs discuss how the data recorded on the form are encoded.

a. **Octant and Location**. The area is identified by either a geographic location or a coded location of the met station. In either case, the location is preceded by a number from the Q code, which designates the octant of the globe in which the station is located. The geographic location of the met station may be determined from a military map and is recorded in degrees and tenths of degrees. If the longitude is equal to 100° or more, the first digit, 1, is dropped. For example, latitude 34°42°N, longitude 98°24'W would be encoded as 1 347984. When operations require that the station be identified by a code, the Q code number 9 is used to signify that the next six digits are a coded location of the met station. The using unit must understand the code used for the location.

b. **Date**. The day of the month is entered in two digits. For example, 25 indicates the message is for the 25th day (GMT) of the month.

c. **Time**. The release time in hours and tenths of hours is entered in three digits. Thus, 138 indicates a release time of 1348 GMT.

FALLOUT MESSAGE
For use of this form, see FM 6-15; the proponent agency is TRADOC.

IDENTIFICATION	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10sM)
METFM	**Q**	**$L_aL_aL_a$ or XXX**	**$L_oL_oL_o$ or XXX**	**YY**	**GGG**	**G**	**hhh**
METFM	**1**	**347**	**984**	**25**	**138**	**0**	**036**

		TRUE WIND				TRUE WIND	
ZONE HEIGHT (METERS)	LINE NUMBER ZZ	DIRECTION (10s MILS) ddd	**SPEED (KNOTS) FFF**	**ZONE HEIGHT (METERS)**	**LINE NUMBER ZZ**	**DIRECTION (10s MILS) ddd**	**SPEED (KNOTS) FFF**
SURFACE	00	**310**	**004**	**16000**	**08**	**635**	**024**
2000	01	**366**	**008**	**18000**	**09**	**035**	**032**
4000	02	**512**	**014**	**20000**	**10**		
6000	03	**571**	**018**	**22000**	**11**		
8000	04	**601**	**012**	**24000**	**12**		
10000	05	**376**	**016**	**26000**	**13**		
12000	06	**379**	**028**	**28000**	**14**		
14000	07	**411**	**024**	**30000**	**15**		

REMARKS

RECEIVED FROM: **FORT SILL MET** | DATE AND TIME (GMT)

DELIVERED TO: **CHEMICAL OFFICER III CORPS**	**25 1600 NOV 91**
RECORDER **JONES**	
CHECKER **SMITH**	

DA FORM 3676-R, MAY 92 PREVIOUS EDITION OF THIS FORM MAY BE USED UNTIL EXHAUSTED.

Figure A-33. DA Form 3676-R

d. **Duration of Validity**. A digit from 1 to 8 is entered to represent duration of validity in hours. Code figure 9 indicates 12 hours. US Forces use the digit 0 since they do not predict how long met messages will be valid.

e. **Station Attitude**. The altitude of the met station above mean sea level is entered in tens of meters. The altitude of the station may be determined from a military map or from the survey section and is encoded in three digits. For example, 036 indicates the station is 360 meters above mean sea level.

f. **Line Number**. The line number is identified by two digits that correspond to the zone number. The first line number, 00, indicates surface; 01, surface to 2,000 meters; 02, 2,000 meters to 4,000 meters; and so on.

g. **True (Zone) Wind Data**. Wind direction is encoded in three digits to the nearest 10 mils. Wind speed is encoded in three digits to the nearest knot. The number 310 indicates the wind direction is 3,100 mils. The number 004 indicates a speed of 4 knots.

h. **Remarks**. The remarks block is used to record other pertinent data.

i. **Message Format for Transmission**. The FOMET message is transmitted in a certain code group format. An example of the format is METFMQ $L_aL_aL_aL_oL_oL_o$ (pause) YYGGGG (pause) hhh (pause) ZZdddFFF (pause) ZZdddFFF, and so on.

Section III
Artillery Limited Surface Observation Met Message

A-18. GENERAL

All FA met sections can produce an artillery limited surface observation (ALSO) met message in support of Army tactical operations. Only surface observation equipment is used to collect the data, which are entered on DA Form 5033-R (LIMITED SURFACE OBSERVATION). A reproducable copy of this form is at the rear of this manual. Met sections deliver the data to requesting agencies in plaintext format. The message will be transmitted in six-digit groups. The order of groups must be maintained. Only the 99 group will be considered optional and may be omitted if not applicable. If an element within a group cannot be reported, it must be entered as a slash. Correct procedures for producing an ALSO met message are described below.

A-19. MESSAGE IDENTIFIER (SUPRP Q)

Use the five-letter SUPRP identifier followed by octant of globe for the first six-letter/number group.

A-20. STATION LOCATION ($L_aL_aL_a$ $L_oL_oL_o$)

In the second six-number group, three numbers are for latitude and three are for longitude to a tenth of a degree. When the location must be coded, the code is in agreement with the receiving and transmitting units.

A-21. DATE AND TIME (YY GGgg)

Both are given in GMT in hours and minutes at time of observation.

A-22. TOTAL AMOUNT OF CLOUD COVER (Na)

Of all the weather conditions that adversely affect aircraft operations, low clouds and low visibility are by far the most common. Sky condition observations consist of two elements, the amount of clouds or obscuration present and remarks about the sky condition in the area that would be helpful to the weather forecaster or to the aviator. This paragraph describes the method of observing the sky conditions.

a. **Sky Cover Amounts (Na)**. The total amount of the sky covered by clouds or an obscuration can be described by using one of the following words:

(1) **Clear**. Less than 1/8 of the sky is covered by clouds.

(2) **Scattered**. 1/8 to less than 1/2 of the sky is covered (approximately 10-50 percent).

(3) **Broken**. 1/2 or more of the sky is covered (approximately 60-90 percent).

(4) **Overcast**. Sky is totally covered by clouds or other materials i.e., fog, blowing snow, blowing sand, or smoke.

b. **Determining Sky Cover**. The total cloud amount is determined by considering the sky above as a celestial dome divided into eight equal parts. For example, the observer is standing at point X in Figure A-34. There are three different cloud layers above you. There is 7/8 cloud cover, but the cirrus and the altocumulus overlap by about 1/8, so the total cloud amount is reported as 6/8, or a broken condition. Table A-19 indicates amount of cloud cover codes.

c. **Additional Codes**. Very often, significant features of sky cover cannot be explained simply by scattered, broken, etc. Explanations for hilly or mountainous stations are included in the code and must be used. These codes, which are extremely important to aircraft operations, are listed in Table A-20.

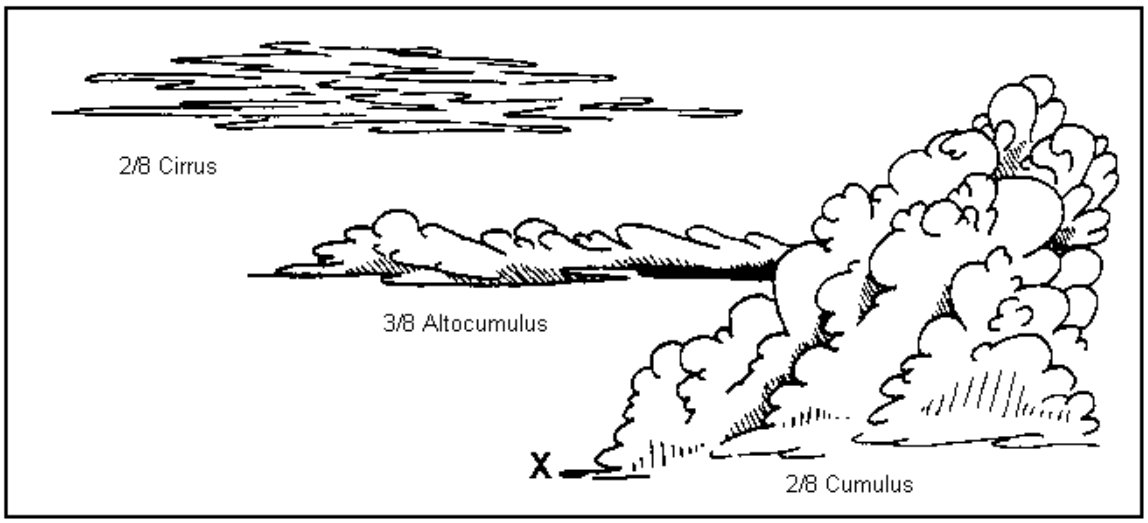


Figure A-34. Cloud Cover

CODE FIGURE	EXPLANATION	FOR WORK SHEET ABBREVIATION
0	Clear (no clouds)	CLR
2	Scattered (1/8 - 4/8)	SCTD
3	Scattered (hills in clouds)	SCTD II
5	Broken (5/8 - 7/8)	BRKN
6	Broken (hills in clouds)	BRKN
7	Overcast (8/8)	OVC
8	Overcast (hills in clouds)	OVC II

Table A-19. Na-Total Amount of Cloud Cover

CODE	DESCRIPTION
3 - Scattered	(Hills in clouds)
6 - Broken	(Hills in clouds)
8 - Overcast	(Hills in clouds)

Table A-20. Additional Codes

A-23. WIND DIRECTION AND SPEED (D F)

Wind speed and direction are necessary in forecasting weather, especially in locations where weather is often associated with frontal systems. Wind direction and speed can be used to locate these fronts and to determine their movement. Frequently, the combination of wind direction and terrain produces significant variation in wind speed over very short distances. Local variations in wind speed can also produce deviations in weather conditions.

a. **Direction (D)**. Wind direction is defined as the direction from which the wind is blowing. Wind may be read from an anemometer. Table A-21 lists the codes for wind direction.

b. **Speed (F)**. Wind speed may also be read from an anemometer. If no wind equipment is available, the speed may be estimated by using Table A-22.

CODE FIGURE	EXPLANATION	DEGREES
0	Calm	
1	NE	023-067
2	E	068-112
3	SE	113-157
4	S	158-202
5	SW	203-247
6	W	248-292
7	NW	293-337
8	N	338-022
9	Variable	

Table A-21. D-Direction from Which Surface Wind is Blowing

CODE FIGURE	DESCRIPTION	SPECIFICATIONS	APPROXIMATE KNOTS
0	Calm	Smoke rises vertically	Less than 2
2	Light Breeze	Wind felt on face and leaves rustle	3-8
4	Moderate breeze	Dust and loose paper fly about; small branches move	9-18
6	Strong breeze	Large branches in motion, whistling in wires	19-29
8	Gale	Twigs broken off trees; progress of person walking generally impeded	30-42

Table A-22. F-Force of Surface Wind (Beaufort Scale)

A-24. VISIBILITY (V)

Visibility is an important limiting factor in flying operations. Poor visibility restricts visual surveillance and flying observations. Visibility is the greatest distance an object can be seen and identified by the normal eye without the aid of optical devices such as binoculars and starlight scopes. In actual practice, visibility is the greatest distance that prominent objects such as trees, buildings, water towers, or natural landmarks (hills) can be seen clearly enough to be identified. Visibility is reported in meters, to the nearest hundred meters, as listed in Table A-23. The visibility that is reported must be representative of at least half of the horizon circle. In making this determination, the horizon circle is normally divided into quadrants as shown in Figure A-35. Any two quadrants may be used to determine the prevailing visibility. Quadrant visibility may be reported as a remark at the end of the observation. If the observer feels that the visibility in one quadrant is significantly different from the prevailing visibility, he should include a remark. For example, Visibility N, meters. Any quadrant or direction may be used for this remark.

CODE FIGURE	EXPLANATION
0	Less than 50 meters
1	50-200 meters
2	200-500 meters
3	5000-1,000 meters
4	1-2 km
5	2-4 km
6	4-10 km
7	10-20 km
8	20-50 km
9	50 km or more

Table A-23. V-Visibility at Surface

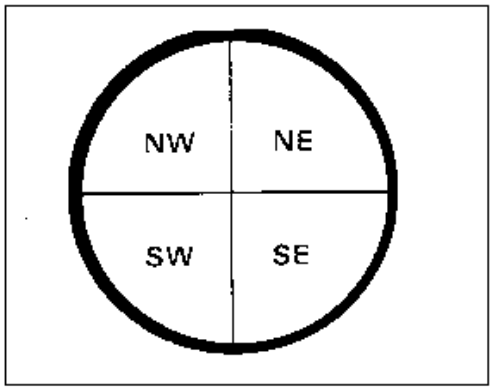


Figure A-35. Quadrant Visibility

b. **Daytime**. In daytime, any building, water tower, telephone pole, road, hill, clumps of trees, etc., that can be seen under ideal conditions may be used as a visibility marker if the distance to the object is known.

c. **Night**. At night**,** the above objects can be used if their silhouettes can be identified. However, the best nighttime marker is an unfocused light at a known distance from the observation point. This does not include searchlights, airport rotating beacons, or automobile headlights aimed directly at you.

A-25. PRESENT WEATHER AND OBSTRUCTIONS TO VISION (w)

The important effect visibility has on operations has already been mentioned. It would not be logical to report a reduction in visibility without describing it in terms of the weather phenomena upon which the visibility depends. These weather phenomena are divided into two main groups, weather and obstructions to vision. They are discussed separately in detail in the following paragraphs. Table A-24 lists the codes for present weather.

CODE FIGURE	EXPLANATION
0	No significant weather
1	Smoke or haze
2	Fog in valley
3	Sandstorm, dust storm, or blowing snow
4	Fog
5	Drizzle
6	Rain
7	Snow or rain and snow mixed
8	Shower(s)
9	Thunderstorm(s) with or without precipitation

Table A-24. w-Present Weather and Obstructions to Vision

a. **Smoke**. Smoke is fine ash particles suspended in the air. When smoke is present, the disk of the sun appears very red at sunset and sunrise and has a reddish tinge throughout the day. Smoke at a distance, such as from a forest fire, usually has light grayish or bluish color.

b. **Haze**. Haze is dust and other material too small to be seen individually by the unaided eye. Haze reduces visibility and resembles a uniform veil over the landscape that subdues the colors. Haze appears bluish against a dark background but dirty or orange against a bright background such as the sun. In contrast, fog appears grayish and feels damp on the skin.

c. **Fog**. Fog is very small drops of water suspended in the air that reduce visibility.

d. **Blowing Sand or Dust**. Blowing sand or dust is dust or sand raised by the wind to such an extent that visibility is impaired.

e. **Blowing Snow**. Blowing snow occurs when there is no appreciable amount of falling snow, but snow from the ground is carried into the air by the wind and visibility is reduced.

f. **Precipitation**. Precipitation includes all forms of moisture that fall to the earth's surface, such as rain, snow, and hail. All forms of precipitation can be classified as liquid, freezing, or frozen. Of special importance are the freezing types of precipitation that present a great hazard to aviation. Precipitation is reported as amplification of phenomenon reported by w. Table A-25 contains the appropiate codes.

CODE FIGURE	EXPLANATION
0	No precipitation occurring
1	Light
2	Heavy
3	In the past hour, but not at the time of observation
4	Precipitation within sight
5	Freezing precipitation
9	Hail or ice pellets

Table A-25. A'-Amplification of Phenomenon Reported by w

(1) **Liquid Precipitation**. There are two forms of liquid precipitation, drizzle and rain. Drizzle is very small water droplets that seem almost to float in the air and visibly follow air motion. Drizzle falls from fog or very low clouds. Rain is precipitation that reaches the earth's surface as relatively large drops. Rain can be classed as light, moderate, or heavy, depending upon the rate of fall.

(2) **Freezing Precipitation**. There are two forms of freezing precipitation, freezing rain and freezing drizzle. Freezing rain is precipitation in the form of very cold raindrops, a portion of which freezes and forms a smooth coating of ice upon striking an exposed surface. Freezing drizzle is precipitation in the form of very cold drizzle that freezes in the same manner as freezing rain.

(3) **Frozen Precipitation**. There are four forms of frozen precipitation, ice pellets, hail, snow, and snow grains. Ice pellets are frozen raindrops formed by rain falling through a layer of cold air. Ice pellets may adhere to any exposed surface, forming an uneven layer of ice. Hail is precipitation in the form of balls or irregular lumps of ice. Hail results when water drops are repeatedly carried aloft to the colder air by the violent air currents usually associated with thunderstorms. Snow is precipitation composed of ice crystals. Snow grains are small grains of snow that are soft and opaque and lack the six-sided appearance of the ordinary snowflake.

g. **Thunderstorms**. A thunderstorm may or may not be accompanied by rain or hail.

h. **Tornado**. A tornado is a circular whirl or wind of great velocity and small horizontal diameter. The horizontal diameter of a tornado varies from a few feet up to a mile, and the wind speeds often exceed 200 mph. Tornadoes are short-lived, usually not lasting more than an hour or two. If a tornado is sighted, the observer should call his reporting station immediately and give its location and direction of movement. Speed in reporting the sighting is of the utmost importance to all concerned.

A-26. STATE OF ROAD IN VICINITY OF OBSERVATION POINT (R)

Table A-26 lists the codes for road conditions.

CODE FIGURE	EXPLANATION
0	Dry
1	Wet
2	Flooded
3	Slush
4	Ice patches
5	Glazed Ice
6	Smow depth 1 to 19 cm
7	Snow depth 20 cm or more
8	Snow drift

Table A-26. R-State of Road in Vicinity of Observation Point

A-27. STATE OF TERRAIN IN VICINITY OF OBSERVATION POINT (T)

Table A-27 lists the codes for terrain conditions.

CODE FIGURE	EXPLANATION
0	Dry
1	Wet
2	Pools of water on surface;
3	Flooded
4	Ground frozen 0 to 4 cm
5	Ground frozen 5 cm or more
6	Snow depth 0 to 4 cm
7	Snow depth 5 to 24 cm
8	Snow depth 25 to 44 cm
9	Snow depth 45 cm or more

Table A-27. T-State of Terrain in the Vicinity of the Observation Point

A-28. STATE OF WATER SURFACE (A)

Table A-28 lists the codes for water surface conditions.

CODE FIGURE	EXPLANATION
0	Water level normal
1	Water level much below normal
2	Water level high, but not overflowing
3	Banks overflowing
4	Floating ice (more than half)
5	Thin ice, complete cover, impassable for persons, 0-4 cm thick
6	Ice, complete cover, passable for persons, depth unknown
7	Ice, complete cover, depth 5-9 cm
8	Ice, complete cover, depth 10-24 cm
9	Ice, complete cover, depth 25 cm or more

Table A-28. A-State of Water Surface

A-29. TEMPERATURE (TT)

Temperature is indicated in whole degrees Celsius. Negative temperatures are encoded by adding 50 to the absolute value of the temperature; i.e., -20° is coded as 70.

A-30. PRESSURE (PPPP)

The surface pressure to the nearest tenth of a millibar is encoded. When pressure is over 1000 mb, the thousands' digit is dropped.

A-31. WIND DIRECTION (dd)

In this portion of the code, the wind direction (in tens of degrees) is reported in two digits. This data is used to further amplify wind information reported in the fourth six-digit group. These two digits will be encoded as 99 when the wind speed is less than 5 knots.

A-32. WIND SPEED (ff)

The wind speed is reported in knots and in two digits.

A-33. AMOUNT OF LOW CLOUD (Nh)

The lowest cloud is determined for the amount of cover in eighths. For encoding, see Table A-29.

CODE FIGURE	EXPLANATION
0	0
1	1/8 or less, but not 0
2	2/8
3	3/8
4	4/8
5	5/8
6	6/8
7	7/8 or more, but not 8/8
8	8/8
9	Sky obscrured or cloud amount cannot be estimated

Table A-29. Nh-Amount of Cloud Reported at Height ha

A-34. HEIGHT OF LOW CLOUD (ha)

The height of the lowest cloud above the observing point is estimated. For encoding, see Table A-30.

CODE FIGURE	EXPLANATION
0	0-99 meters
1	100-199 meters
2	200-299 meters
3	300-399 meters
4	400-499 meters
5	500-599 meters

6	600-699 meters
7	700-799 meters
8	800-899 meters
9	900 meters or more or no clouds

Table A-30. ha-Height of the Lowest Cloud Layer above the Observation Point

A-35. INDICATOR FOR SURF DATA (99)

When the unit is located at a seacoast area, it is important to give surf conditions. The 99 group indicates that surf data will follow. The surf data includes average height of breakers, time breakers last, direction of waves' approach to beach, and the width of the surf zone. For estimation and encoding of these variables, see Tables A-31, A-32, A-33, and A-34. When surf data is not available, the message will end with height of low cloud plus any remarks on weather elements that might seem appropriate. Thus, the message includes seven six-digit groups when surf data is not included. Any data or weather element that is missing is represented by a slash (/).

CODE FIGURE	EXPLANATION
0	0 to 10 seconds
1	10 to 20 seconds
2	20 to 30 seconds
3	More than 30 seconds

Table A-31. Hs-Average Height of Breakers

CODE FIGURE	EXPLANATION
0	Less than 1 meter
1	1-2 meters
2	2-3 meters
3	More than 3 meters

Table A-32. Ps-Period of Breakers (Seconds) Time Required for Successive Breakers to Pass a Given Point

CODE FIGURE	EXPLANATION
0	Waves approaching from right side
1	Waves approaching directly from rear
2	Waves approaching from lift side

Table A-33. Dw-Direction of Approach of Waves to Beach (Observers Back to Sea)

CODE FIGURE	EXPLANATION
0	1 to 10 meters
1	10 to 20 meters
2	29 to 30 meters
3	More than 30 meters

Table A-34. Ws-Width of Surf Zone (Distance from Edge of Water to the Point Seaward that the White Caps of the Surf Begin to Appear)

A-36. PLAIN LANGUAGE REMARKS

Any remark that the observer considers beneficial or explanatory may be listed at the bottom of the message. Some examples include:

- The direction of a thunderstorm from your location and the approximate direction it is moving toward, e.g., Thunderstorms E moving NE.

- The direction of lightning from your location, e.g., Lightning overhead and SW through NW.

- Obscuring phenomena at a distance from your location but not occurring at your location, e.g., Fog bank NE through SE.

A-37. DA FORM 5033-R LIMITED SURFACE OBSERVATION

Figure A-36 is a DA Form to be completed for each limited surface observation.

Section IV
Met Message Checking Procedures

Met section personnel perform quality control checks of all data and met messages. However, anyone receiving met messages should question any peculiarities noticed on his copy. Anytime there is doubt about the timeliness and/or validity of a met message, the met section should be consulted. Met section personnel are qualified to explain and/or correct message variations or transmission errors. Voice dissemination of messages often induces copying errors, especially when other than the standard met message forms are used to copy the messages.

A-38. GENERAL

All met messages are processed automatically. Once the instrument is released, met section personnel can monitor the raw data but cannot edit it. If any peculiarities appear on the final message, the met station leader can extract the flight data and look for any abnormal conditions that could explain the peculiarity. If the met station leader has any doubts, another sounding can be made to verify data. Consecutive soundings should show a trend unless weather conditions have changed because of rain, snow, a rapid increase or decrease in cloud cover, the passage of a front, or a sunrise or sunset transition period.

A-39. MET MESSAGE PARTS

Met messages are divided into the message heading and message body. The message heading identifies the met station location, the area of validity of the message, and the time of the message. The message body contains the met data element of the specific message.

A-40. CHECKING THE MESSAGE HEADING

In general, the procedures for checking the heading of the met message are the same for all types of messages. These procedures are discussed below.

a. **Location**. The location of the met station and the octant in which the message is valid check to ensure it is valid for your area of operation.

b. **Date and Time**. The date and time entries are checked to ensure that the met data in the message are current. If the message is over 4 hours old, the validity of the message is verified with the met section or obtain an updated message from them.

NOTE: The date and time are Greenwich mean time, not local standard time.

c. **Altitude**. The altitude of the met section should be checked on the map. An altitude error of 50 meters or more can affect temperature and density accuracy.

d. **Pressure**. The pressure on the ID line should compare within 1 mb of the pressure on line 00. This does not apply to ballistic messages since all lines except the heading are reported in density percent of standard.

A-41. CHECKING THE MESSAGE BODY

The procedures for checking the message body vary with each type of message. Procedures for checking the message body of specific types of met messages are discussed below.

a. **Computer Met Message**. The computer met message is a record of actual measured weather conditions. Therefore, it is more likely to show abrupt changes not noticed on the ballistic met message.

(1) Wind speeds and directions should be fairly uniform with proportional changes in altitude. Large changes in wind direction (1,000 mils when wind speeds are above 10 knots) or abrupt increases or decreases in wind speeds (10 to 15 knots) are suspect and should be investigated.

NOTE: Large changes in wind direction are not uncommon with wind speeds less than 10 knots.

(2) Temperature accuracy is hard to evaluate because of natural erratic changes. Any severe increase or decrease in temperature (for example, +/- 20°K) is suspect and should be investigated.

(3) Atmospheric pressure always decreases from line to line. Pressure never increases with height. Transposed figures are the most common errors in pressure values. If errors in pressure are suspected, the met section must provide the corrected values.

b. **Ballistic Met Message**

(1) Ballistic wind directions should remain fairly constant from line to line. Drastic changes (greater than 1,000 mils) or sudden reversals in direction should be questioned, particularly if the wind speeds on those lines are greater than 10 knots. Ballistic wind speed changes greater than 15 knots from line to line should be questioned.

(2) Ballistic temperatures and densities should trend smoothly with no drastic changes between zones. Normally, as density increases, temperature decreases. Rarely will both temperature and density change in the same direction. If they do, those lines are suspect and should be verified by the met section. Drastic changes in density or temperature (2.0 percent or more) should be verified by the met section.

c. **Other Met Messages**. The data in each of the other types of met messages are not easily checked by the user. For each of these messages if the message heading has been checked, the data provided should be considered correct without further checking.

LIMITED SURFACE OBSERVATION										DATE:	
	IDENTIFIER	OCTANT Q *a*	LATITUDE $L_aL_aL_a$ *b*	LONGITUDE $L_oL_oL_o$ *c*	Date (GMT) YY d	TIME (GMT) GGgg e	TOTAL AMOUNT OF CLOUD COVER Na (Table A-19) f	WIND DIRECTION D (Table A-21) g	WIND SPEED F (Table A-22) h	VISIBILITY V (Table A-23) i
1	ACTUAL CONDITIONS									
2	SUPRP									
	IDENTIFIER	PRESENT WEATHER w (Table A-24) j	AMPLIFICATION OF PRESENT WEATHER A (Table A-25) k	STATION HEIGHT HHH l	ROAD CONDITIONS R (Table A-26) m	TERRAIN CONDITIONS T (Table A-27) n	STATE OF WATER SURFACE A (Table A-28) o	AIR TEMPERATURE TT p	PRESSURE PPPPP q	WIND DIRECTION dd r
3	ACTUAL CONDITIONS									
4	SUPRP									
	IDENTIFIER	WIND SPEED ff *s*	AMOUNT OF LOWEST CLOUD Nh (Table A-29) *t*	HEIGHT OF LOWEST CLOUD ha (Table A-30) *u*	INDICATION FOR SURF DATA 99 *v*	AVERAGE HEIGHT OF BREAKERS (Meters) Hs (Table A-31) *w*	PERIOD OF BREAKERS (SECONDS) Ps (Table A-32) *x*	DIRECTION OF WAVES Dw (Table A-33) *y*	WIDTH OF SURF ZONE Ws (TableA-34) *z*	
5	ACTUAL CONDITIONS									
6	SUPRP									
REMARKS:										

DA FORM 5033-R, 1 Dec 81

Figure A-36. Limited Surface Observation Form

Appendix B
World Meteorological Organization Cloud Codes

This appendix provides the necessary tables and specific instructions to record cloud phenomena for the surface "41414 $N_hC_LhC_MC_H$" group. This guidance assumes minimal previous knowledge of synoptic code procedures; however, a basic understanding of clouds is necessary. For those already familiar with synoptic codes, some departure from conventional World Meteorological Organization coding procedures will be noticed. By simply observing the elements requested and reporting them according to tables provided in this text, the intent of the cloud entry will be fully met.

CLOUDS GROUP FORMAT

The clouds entry is a five-digit, mandatory group. All five digits must be entered, regardless of the presence or absence of clouds. The WMO format for entry of clouds has been modified to meet National Climatic Data Center requirements. All stations should follow this modified format, regardless of location. A description of the five-digit format follows:

a. **N_h**. N_h is the amount (in oktas) of the sky covered by all low clouds (C_L) observed or the amount of sky covered by all the middle clouds (C_M) observed. In no case will the amounts of the low and middle clouds be combined to report N_h. Use Table B-1 to report the amount of low or middle cloud coverage.

Code Figure	Cloud amount in oktas (eighths)	Cloud amount in tenths
0	0	0
1	1 okta or less, but not zero	1/10 or less
2	2 oktas	2/10 - 3/10
3	3 oktas	4/10
4	4 oktas	5/10
5	5 oktas	6/10
6	6 oktas	7/10 - 8/10
7	7 oktas or more,but not 8 oktas	9/10 or more,but not 10/10
8	8 oktas	10/10
9	Sky obscured by fog and/or other meteorological phenomena	
/	Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena	

Table B-1. Amount of Low/Middle Cloud, N_h

NOTE: If there are any breaks in the sky at all, such as an overcast with a mackerel sky (altocumulus pelucidus or stratocumulus pelucidus), N_h would be encoded as 7. If there are only a few patches of low or middle cloud in the sky, N_h cannot be encoded as 0 but is encoded as 1. A partial obscuration does not affect the coding of N_h. A total obscuration is coded as 9, not 8 (overcast sky).

b. **C_L**. C_L is the type of low cloud, based on the priority given in Table B-2. This table presents the specifications for type of low cloud, C_L, in order of priority. Go down the table and use the first applicable code figure. A slash (/) is reported if C_L clouds are not visible owing to fog or similar obscuring phenomena.

Code Figure	Coding Criteria

CUMULONIMBUS PRESENT, WITH OR WITHOUT OTHER C_L CLOUDS	
C_L = 9	If the upper part of at least one of the cumulonimbus clouds present is clearly fibrous or striated, use C_L = 9.
C_L = 3	If the upper part of none of the cumulonimbus clouds present is clearly fibrous or striated, use C_L=3.
NO CUMULONIMBUS PRESENT	
C_L = 4	If stratocumulus formed by the spreading out of cumulus is present, use C_L = 4.
C_L = 8	If the C_L code figure 4 is not applicable and if cumulus and stratocumulus clouds with bases at different levels are present, use C_L = 8.
C_L = 2	If the C_L code figures 4 and 8 are not applicable and if cumulus clouds of moderate or strong vertical extent are present, use C_L = 2.
C_L = 1	If the C_L code figures 4, 8, and 2 are not applicable, use C_L = 1, if the C_L clouds present are predominantly (NOTE 1) cumulus with little vertical extent and seemingly flattened or ragged cumulus other than of bad weather (NOTE 2), or both.
C_L = 5	Use C_L = 5, if among other C_L clouds present, stratocumulus other than that formed by the spreading out of cumulus of predominant.
C_L = 6	Use C_L = 6, if the C_L clouds present are predominantly stratus in a more or less continuous sheet or layer, or in shreds (stratus of bad weather), or both.
C_L = 7	Use C_L = 7, if the C_L clouds present are predominantly pannus (ragged shreds of stratus of bad weather or ragged cumulus of bad weather), or both.
0	No C_L clouds - No cumulus, cumulonimbus, stratocumulus, or stratus.
/	C_L clouds not visible owning to fog or similar obscuring phenomena.
NOTE 1: Consideration of predominance is restricted to the clouds corresponding to C_L code figures 1, 5, 6, and 7, which have the same priority. Clouds of any one of these four specifications are said to be predominant when their sky cover is greater than that of the clouds of any of the other three specifications. NOTE 2: Bad weather denotes the conditions which generally exist during precipitation and a short time before and after.	

Table B-2. Coding of Low Cloud, C_L

NOTE: Clouds are divided into three families, and classified as low, middle, or high. The general height ranges for these are surface to 6500 feet for low, 6500 feet to 20000 feet for middle, and above 20000 feet for high. Remember, these ranges are not absolute, but given as a guide only. More consideration may be given to the cloud form than the height in many cases. Each cloud family is coded with a single digit, 0 through 9. The code figure 0 is used to indicate that clouds are not present for a given family.

c. h = Height of the base of the lowest cloud seen. The height reported is with respect to the surface. The height is coded as a solidus (/) if there is a total surface-based obscuration that prevents an observation of the clouds. Use Table B-3 for the cloud base height.

d. **C_M**. C_M is the type of middle cloud, based on priority given in Table B-4. This table presents the specifications for type of middle cloud, C_M, in order of priority. Go down the table and use the first applicable code figure.

Code Figure	Reportable Heights (ft)

0	0 or 100
1	200 or 300
2	400 or 600*
3	700 to 900*
4	1000 to 1900*
5	2000 to 3200*
6	3300 to 4900*
7	5000 to 6500**
8	7000 to 8000**
9	8500 or higher or no clouds
/	unknown or base of clouds below surface of station
*	reported in 100-foot increments
**	reported in 500-foot increments

NOTE 1: This group is used to report the height of the base of the lowest cloud seen, regardless of cloud amount. The height reported is with respect to the surface.
NOTE 2: The lowest cloud height is coded with a solidus (/) if there is a total surface-based obscuration that prevents an observation of the clouds.

Table B-3. Height of Cloud Base Above Ground, h

A solidus (/) is reported if C_M clouds are not visible owing to fog or similar obscuring phenomenon, or because of a continuous layer of lower clouds.

Code Figure	Coding Criteria
	ALTOCUMULUS PRESENT
C_M = 9	If the sky is chaotic, use C_M = 9.
C_M = 8	If the C_M code figure 9 is not applicable and if altocumulus with sprouting in the form of turrets or battlements or altocumulus having the appearance of small cumuliform tufts is present, use C_M = 8.
C_M = 7*	If the C_M code figures 9 and 8 are not applicable and if altostratus or nimbostratus is present together with altocumulus, use C_M = 7.
C_M = 6	If the C_M code figures 9, 8, and 7 are not applicable and if altostratus formed by the spreading out of cumulus or cumulonimbus is present, use C_M = 6.
C_M = 5	If the C_M code figures 9, 8, 7, and 6 are not applicable and if the altostratus present is progressively invading the sky, use C_M = 5.

**There are several definitions of C_M = 7 and each has a different priority; therefore, C_M = 7 appears several times in this code table.	
C_M = 4	If the C_M code figures 9, 8, 7, 6, and 5 are not applicable and if the altostratus present is continually changing in appearance, use C_M = 4.
C_M = 7	If the C_M code figures 9, 8, 6, 5, and 4 are not applicable and if the altostratus present occurs at two or more levels, C_M = 7.
C_M = 7, 3	If the C_M code figures 9, 8, 6, 5, and 4 are not applicable and if the altocumulus present occurs at one level, use C_M = 7 or 3 depending on whether the greater part of the altocumulus is respectively opaque or semi-transparent.
	NO ALTOCUMULUS PRESENT
C_M = 2	If nimbostratus is present or if the greater part of the alto stratus present is opaque, use C_M = 2.
C_M = 1	If there is no nimbostratus and if the greater part of the altostratus present is semi-transparent, use C_M = 1.
C_M = 0	No C_M clouds - No altocumulus, altostratus, or nimbostratus.
/	C_M clouds not visible owing to fog or similar obscuring phenomena or because of a continuous layer of lower clouds.

Table B-4. Coding of Middle Cloud, C_M

e. **C_H**.= C_H is the type of high cloud, based on priority given in Table B-5. This table presents the specifications for type of high cloud, C_H, in order of priority. Go down the table and use the first applicable code figure. A solidus (/) is reported if C_H clouds are not visible owing to fog or similar obscuring phenomenon, or because of a continuous layer of lower clouds.

Code Figure	Coding Criteria
	ALTOCUMULUS PRESENT
C_H = 9	If cirrocumulus is present alone or is more than the combined sky cover of any cirrus and cirrostratus present, use C_H = 9.
	CIRROSTRATUS PRESENT
C_H = 7	If the cirrostratus covers the whole sky, use C_H = 7.
C_H = 8	If the cirrostratus does not cover the whole sky and is not invading the celestial dome, use C_H = 8.
C_H = 6	If the cirrostratus is progressively invading the sky and if the continuous veil extends more than 45 degrees above the horizon but does not cover the whole sky, use C_H = 6.
C_H = 5	If the cirrostratus is progressively invading the sky but the continuous veil does not reach 45 degrees above the horizon, use C_H = 5.

	NO CIRROSTRATUS PRESENT
C_H = 9	Not applicable.
C_H = 4	If the cirrus clouds are invading the sky, use C_H = 4.
C_H = 3	If the C_H code figure 4 is not applicable and if dense cirrus which originated from cumulonimbus is present in they sky, use C_H = 3.
C_H = 2, 1	If the code figures 4 and 3 are not applicable: Use C_H = 2, if the combined sky cover of dense cirrus, of cirrus with sprouting in the form of small turrets or battlements, and of cirrus of tufts is greater than the combined sky cover of cirrus in the form, of filaments, strands, or hooks. Use C_H = 1, if the combined sky cover of cirrus in the form of filaments, strands, or hooks is greater than the combined sky cover of dense cirrus, of cirrus with sprouting in the form of small turrets or battlements, and of cirrus in tufts.
C_H = 0	No C_H clouds - No cirrus, cirrostratus, or cirrocumulus.
/	C_H clouds not visible owing to fog or similar obscuring phenomena or because of a continuous layer of lower clouds.

Table B-5. Coding of High Cloud, C_H

Appendix C
Met Support Request Procedures

This appendix implements STANAG 4103 and QSTAG 1166.

Normally, automatic distribution of all met messages is made digitally to all users or is made by broadcasting them on a specific schedule. Some users, especially firing units, may have an immediate need for met data before being placed on automatic distribution. They may request met support by using the procedures in this appendix.

C-1. SUBMISSION OF MET SUPPORT REQUESTS

All requests for met support should be forwarded through the S3 to the appropriate met section. Requests should state who should eventually receive the met data. To ensure receipt of appropriate met information, the unit requesting met support should state specifically in the initial request what information is needed, the delivery time, and the method of delivery. The number of lines requested should be no greater than the number required for the maximum ordinate expected to be fired. Requests for met should be submitted as far in advance as possible. Also units must realize met messages are provided on time schedules based on GMT, not local time. The structure for a request for met support is shown in Figure C-1. The standard format for met requests provides the following:

- Type of message.
- Intervals between messages.
- Lowest and highest lines required.
- Time request is terminated.

Group 1	**METRKQ**
Group 2	**$L_aL_aL_aL_oL_oL_O$ or XXXXX**
Group 3	**$Y_oY_oG_oG_oG_1G_1$**
Group 4	**$Z_oZ_oZ_1Z_1J_oJ_1$**

Figure C-1. Message Request Structure

C-2. DEFINITION OF SYMBOLS

The symbols in the message request for met support are defined in Table C-1 in the order in which they appear. The Q code for octant of the globe is defined in Table C-2. Table C-3 lists the line codes for the type 2 or 3 ballistic met message. Table C-4 lists the zone number codes for a TA met message. Table C-5 lists the zone codes for a computer met message. Figure C-2 shows an example and provides an explanation of a request for a met message.

SYMBOL	DEFINITION
MET	Designates message category-met.
R	Designates request.
K	Designates type of message as follows:
	• 2-surface to air (type 2 ballistic). • 3-surface to surface (type 3 ballistic). • 6-target acquisition. • 9-computer.
Q	Designates octant of the globe in which requesting unit is located. (See Table C-2.)
$L_aL_aL_a$	Designates latitude of requesting unit to the nearest tenth of a degree.
$L_oL_oL_o$	Designates longitude of requesting unit to the nearest tenth of a degree. For

XXXXXX	longitudes of 100° and greater, the hundreds digit is dropped. or Location of the center of the area of applicability in code.
Y_oY_o	Designates day of month (GMT) on which delivery of first message is required.
G_oG_o	Designates time (GMT) to the nearest hour of day (Y_oY_o) at which delivery of the first message is required.
G_1G_1	Designates time (GMT) to the nearest hour on the last day on which final message is required. (See J_o to determine date.)
Z_oZ_o	Designates lowest line required in the message is 00 (surface) for all messages.
Z_tZ_t	Designates highest line code required. See Tables C-3, C-4, or C-5 for the type message requested by K.
J_o	Designates the number of days from 0 to 9 that must be added to Y_oY_o to find the last day for which met message support is required. The hour of the last day is determined by G_1G_1 above.
J_1	Designates time interval, in hours, between messages. Numbers 1 through 8 indicate hourly intervals, and 9 indicates a 12-hour interval. When only one message is required, G_1G_1 is the same as G_oG_o and J_o and J_1 are 0.

Table C-1. Symbols in Message Request for Met Support

Q CODE	OCTANT LOCATION
0	North latitude-0° to 90° west longitude
1	North latitude-90° to 180° west longitude
2	North latitude-180° to 90° east longitude
3	North latitude-90° to 0° east longitude
4	Not used
5	South latitude-0° to 90° west longitude
6	South latitude-90° to 180° west longitude
7	South latitude-180° to 90° east longitude
8	South latitude-90° to 0° east longitude
9	To be used when the location of the met station is not indicated by latitude and longitude

Table C-2. Q Code for Octant of the Globe

LINE-CODE Z_tZ_t	METERS	LINE-CODE Z_tZ_t	METERS
00	0	08	5,000
01	200	09	6,000
02	500	10	8,000
03	1,000	11	10,000
04	1,500	12	12,000
05	2,000	13	14,000
06	3,000	14	16,000
07	4,000	15	18,000

Table C-3. Line Codes for Ballistic Met Messages (Type 2 or 3)

	HEIGHT OF MIDPOINT OF ZONE ABOVE MDP (METERS)	HEIGHT ABOVE MDP OF ZONE

Z_tZ_t		(METERS)	
		Base	Top
00	0	-	-
01	25	0	50
02	75	50	100
03	150	100	200
04	250	200	300
05	350	300	400
06	450	400	500
07	550	500	600
08	650	600	700
09	750	700	800
10	850	800	900
11	950	900	1,000
12	1,050	1,000	1,100
13	1,150	1,100	1,200
14	1,250	1,200	1,300
15	1,350	1,300	1,400
16	1,450	1,400	1,500
17	1,550	1,500	1,600
18	1,650	1,600	1,700
19	1,750	1,700	1,800
20	1,850	1,800	1,900
21	1,950	1,900	2,000
22	2,050	2,000	2,100
23	2,150	2,100	2,200
24	2,250	2,200	2,300
25	2,350	2,300	2,400
26	2,450	2,400	2,500
27	2,550	2,500	2,600

Table C-4. Zone Number Codes for Target Acquisition Met Message

Z_tZ_t	HEIGHT ABOVE MDP OF MIDPOINT OF ZONE (METERS)	HEIGHT ABOVE MDP FROM BASE TO TOP OF ZONE (METERS)
00	0	0
01	100	0 to 200
02	350	200 to 500
03	750	500 to 1,000
04	1,250	1,000 to 1,500
05	1,750	1,500 to 2,000
06	2,250	2,000 to 2,500
07	2,750	2,500 to 3,000
08	3,250	3,000 to 3,500
09	3,750	3,500 to 4,000
10	4,250	4,000 to 4,500
11	4,750	4,500 to 5,000
12	5,500	5,000 to 6,000
13	6,500	6,000 to 7,000
14	7,500	7,000 to 8,000

15	8,500	8,000 to 9,000
16	9,500	9,000 to 10,000
17	10,500	10,000 to 11,000
18	11,500	11,000 to 12,000
19	12,500	12,000 to 13,000
20	13,500	13,000 to 14,000
21	14,500	14,000 to 15,000
22	15,500	15,000 to 16,000
23	16,500	16,000 to 17,000
24	17,500	17,000 to 18,000
25	18,500	18,000 to 19,000
26	19,500	19,000 to 20,000

Table C-5. Zone Number Codes for Computer Met Messages

EXAMPLE

The following is an example of a request for a met message.

METR31
345903
050816
000624

An example of the request for met support is as follows:

- **Group 1**. Ballistic met message is requested for surface-to-surface fire applicable to the Northern Hemisphere between 90°W and 180°W. The octant code is explained in Table C-2.
- **Group 2**. Location of the requesting unit is 34°30' N and 90°18'W.
- **Group 3**. Delivery of the first message is required on the fifth day of the month at 0800 GMT. Delivery of the last message is required at 1600 on the seventh day of the month. (To determine the seventh day, see group 4 below.)
- **Group 4**. The lowest line requested is 00, and the highest line requested is 06. In addition to day Y_oY_o, the message is required for 2 additional days. (In this message, met information is requested for the fifth [original day], sixth, and seventh days [2 additional days].) The time interval between messages is 4 hours.

Figure C-2. Met Message Request

Appendix D
Example Met Plan

The met plan contains the information needed to understand how met assets will be employed. This appendix shows an example of a met plan. Table D-1 lists acronyms and abbreviations for the example met plan.

admin	=	administrative
intel	=	intelligence
log	=	logistics
mech	=	mechanized
PSY	=	psychological
PSYOP	=	psychological operations

Table D-1. Acronyms and Abbreviations

EXAMPLE MET PLAN

(Classification)

TAB F (MET PLAN) TO APPENDIX 3 (FA SUPPORT PLAN) TO ANNEX C (FIRE SUPPORT) TO OPORD 96-3, 52d Mech Div.

REFERENCE: Map, series JWT 128, MONROVIA, sheet 3 (DURIEN), edition 2, 1:50, 000.

Time Zone Used Throughout the Order: BRAVO.

1. SITUATION

a. Enemy Forces. Annex A (Intelligence) to OPORD 96-3.

b. Friendly Forces

(1) 52d Mech Div attacks to secure crossings over the RAMUZZA River and destroys enemy in zone.

(2) Attachments and detachments are as follows:

(a) Section-1 is attached for admin and log support to 1-12th FA.

(b) Section-2 is attached for admin and log support to 1-10th FA.

2. MISSION

The met sections of the 52d Inf Divarty will provide met data support to US and allied forces (artillery) and to the USAF.

3 EXECUTION

a. Concept of Operation. Met support will be provided on a continuous basis with requirements split between the two met sections.

(1) Section 1 will provide automatic 2-hour type 3 ballistic and computer met messages for artillery fires. Direct coordination with firing batteries is required for special operations. Unless otherwise requested, flights will be 3,000 meters altitude (line 6 [type 3 ballistic] and line 7 [computer]). Coordination with allied sound and/or artillery units require direct coordination for both receipt and delivery of met data for artillery fires and allied sound ranging.

(Classification)

(Classification)

TAB F (MET) TO APP 3 (FA SPT) TO ANX C (FIRE SPT) TO OPORD 96-3, 52d Mech Div.

(2) Section 2 will provide high-altitude met data for radiological fallout forecasts and met messages for USAF at 12-hour intervals or as requested by the using G2, S2, or staff weather offices. Met messages for artillery firing and sound data and TA data will be generated from the same sounding (ballistic type 2 and type 3, computer, and sound). Additional met data for artillery firing will be required at other times, as scheduled by individual units (US and allied) through divarty S3. Special limited surface observations will be provided for smoke and chemical operations, as requested directly by the USAF.

(3) Divarty S3 will coordinate all met section displacements and other movements by echelons to provide uninterrupted flow of met data.

(4) Target acquisition met data will be developed on a 4-hour schedule. It will be generated at the same time as ballistic data by both sections.

(5) Special met data requests will be processed through divarty S3 for PSYOP units, and either section will be tasked (PSYOP/leaflet drops).

(6) Divarty S3 will establish liaison with any adjacent allied artillery units and/or met sections to provide a receipt of ballistic, computer, and fallout data whenever similar data are not available from organic met sections.

b. Coordinating Instructions

(1) Priority of met is 7 lines computer and 6 lines ballistic, up to 3,000 meters. These messages will be provided on a 2-hour basis unless otherwise coordinated with firing units by both met sections. USAF support and radiological fallout will be provided by section-2 in addition to firing met data.

(2) All firing elements within the sector of operations and spatial validity of met section locations will be provided met support.

(3) There will be direct coordination among both met sections, the firing battalions, and the divarty S3 regarding radiosonde frequencies, radio frequencies, and movements of met sections.

(4) The divarty S3 will position the two met sections to provide optimum coverage for all firing units (US and allied) radar, UAV, smoke units, USAF, intel sections, and other met users.

_____
(Classification)

_____
(Classification)

TAB F (MET) TO APP 3 (FA SPT) TO ANX C (FIRE SPT) TO OPORD 96-3, 52d Mech Div.

4. SERVICE SUPPORT

a. All met-specific Class IX parts and expendable items will be routed from the divarty S4 through artillery battalions down to the requesting met section. Organizational maintenance will be performed by on-hand unit maintenance personnel. Direct support maintenance will be provided by the direct support battalion.

b. Divarty S4 will monitor low-density, met-specific parts and expendable items and cross-level between met sections, as required.

5. COMMAND AND SIGNAL

a. Command. 52d Divarty S3 will direct all met operations.

b. Signal

(1) Current SOI in effect.

(2) Automatic direct radio data link will be established for all firing units.

(3) FM voice (secure) alternate.

(4) Landline in effect when met sections collocate with firing units.

_____
(Classification)

Appendix E
Data Collection Tables and Procedures for Constructing Standard Atmosphere Table 2 for the AN/TMQ-31

This appendix describes data collection, standard atmosphere tables, and the procedures for constructing the standard atmosphere table used by the meteorological data system met section in the pilot balloon operating mode.

E-1. ATMOSPHERE ZONE DATA COLLECTION TABLE

The MDS AN/TMQ-31 can produce the zone-to-zone raw data it uses in computing met messages. These data are in the data collection tables for the different atmospheric zones. By using the two-digit command TA on the keyboard assembly, the operator can obtain the data. These data are used to construct the standard atmosphere table (Table 2) for the MDS. The data also can be used to verify the flight. The standard atmosphere table contains a vast amount of information that can be checked or used in other met areas.

a. **Table Structure**. The standard atmosphere table is composed of three sections: header line data, met data, and wind data.

(1) **Section 1, Header Line Data**. Section 1 contains the information for the location of the met section and the date and time of the met message. Also included in the header line are the data related to surface conditions at the time of the flight. The format of the header line is shown in Figure E-1. The header line symbols are defined in Table E-1.

MM/DD/YY/HHmm O LLLlll hhhh PPPP.P TT.T RR www ss BBB dddd

Figure E-1. Header Line Format

SYMBOL	DEFINITION
MM	Month of year
DD	Day of month
YY	Year
HHmm	Time of release (hours and minutes)
O	Octant of release point
LLLlll	Coded location (or latitude and longtitude)
hhhh	Height of release point above sea level
PPPP.P	Release point pressure (mb)
TT.T	Release point temperature (Celsius)
RR	Release point relative humidity (percent)
www	Release point wind direction (degrees)
ss	Release point wind speed (knots)
BBB	Bearing to release point (degrees)
dddd	Distance to release point (meters)

Table E-1. Header Line Symbols

(2) **Section 2, Met Data**. Section 2 contains meteorological significant information from the atmospheric zones. The format of the met data section is shown in Figure E-2. The symbols for the met data section are defined in Table E-2. These data include the following:

- Altitude.
- Pressure.
- Temperature.
- Virtual temperature.
- DP temperature.
- Refractivity for each zone.

(3) **Section 3, Wind Data**. Section 3 contains information used to calculate wind speed and direction. The format of the wind data section is shown in Figure E-3. The symbols for the wind data section are defined in Table E-3. The data collected in this section are as follows:

- Zone boundary altitudes.
- Changes in easting and northing positions of the sounding balloon.
- Time in seconds balloon crossed zone boundary.

AAAAA pppp.pp ttt.tt vvv.vv xxx.xx rrr.rr

Figure E-2. Met Data Section Format

SYMBOL	DEFINITION
AAAAA	Altitude of balloon (meters)
pppp.pp	Pressure at balloon altitude (mb)
ttt.tt	Temperature at balloon altitude (K)
vvv.vv	Virtual temperature at balloon altitude (k)
xxx.xx	Dew point temperature at balloon altitude
rrr.rr	Refractivity at balloon altitude (N units)

Table E-2. Met Data Section Symbols

zzzzz eeeeee.ee nnnnnn.nn ssss.ss

Figure E-3. Wind Data Section Format

SYMBOL	DEFINITION
zzzzz	Zone boundary altitude (meters)
eeeeee.ee	Balloon easting position (meters)
nnnnnn.nn	Balloon northing position (meters)
ssss.ss	Time balloon crossed zone boundary (seconds)

Table E-3. Wind Data Section Symbols

b. **Sample Table**. Figure E-4 shows a sample atmospheric zone data collection table. It is a continuous printing by the MDS computer.

NOTE: On the Table 2 computation work sheet, the atmospheric zone data collection table is referred to as the TA table.

TA

07/20/89/1847 1 214577 5 1016.0 26.0 92 60 10 355 40

0	1016.00	298.69	301.86	296.36	392.17
29	1012.62	298.69	301.86	296.30	381.19
57	1009.31	298.69	301.86	296.23	379.89
86	1006.06	298.61	301.75	296.08	378.11
115	1002.75	298.28	301.41	296.00	377.17
144	999.50	298.00	301.12	295.87	375.91
173	996.25	297.87	300.95	298.72	374.27
202	992.94	297.59	300.64	295.37	371.47
308	981.06	296.97	299.91	294.59	364.11
410	969.75	296.06	298.95	294.20	359.95
511	958.69	295.22	298.11	294.16	358.12
612	947.56	294.27	297.09	293.61	353.20
716	936.37	293.39	296.11	292.89	347.05
816	925.56	292.53	295.14	292.03	340.31
918	914.69	291.64	294.12	291.14	333.59
1020	904.00	291.44	293.92	290.94	329.91
1121	893.50	290.94	293.36	290.45	325.05
1226	882.56	290.58	292.97	290.08	320.69
1327	872.31	289.98	292.30	289.36	314.95
1427	862.12	289.36	291.61	288/.72	309.77
1530	851.81	288.87	291.08	288.23	305.22
1631	841.81	288.50	290.64	287.62	300.11
1733	831.81	288.39	290.50	287.22	295.61
1834	822.00	288.37	290.48	287.08	292.33
1936	812.25	287.81	289.92	286.86	289.42
2036	802.69	287.39	289.47	286.44	285.45
2290	778.94	285.44	287.33	284.66	273.73
2545	755.81	285.12	286.73	281.83	257.08
2796	733.50	283.03	284.77	282.58	255.97
3021	713.94	281.61	283.20	281.06	246.77
3272	692.69	280.95	282.45	279.67	236.98
3524	671.87	279.91	281.19	277.12	224.83
3779	651.37	278.59	279.81	275.94	217.22
4036	631.37	278.09	278.98	271.53	202.28
4288	612.12	276.50	277.20	268.00	192.06
4467	598.75	275.62	276.25	266.02	186.09
4719	580.44	273.72	274.28	264.25	180.03
4975	562.25	271.92	272.58	266.05	178.48
5229	544.56	269.50	270.17	265.97	175.05
5731	510.94	266.44	267.00	263.20	163.84
5934	497.94	266.86	266.98	245.30	148.00
6365	471.19	264.34	264.48	245.52	141.66
6681	452.31	262.16	262.27	242.58	136.47
6976	435.31	260.23	260.34	243.05	132.53
7480	407.31	255.30	255.39	241.31	126.20
7634	399.00	254.70	254.78	239.02	123.48
8139	372.87	251.95	252.00	235.03	116.16
8545	352.87	249.59	249.64	232.55	110.73
8694	345.75	248.64	248.69	231.73	108.86
9196	322.62	244.36	244.39	228.16	103.12

Figure E-4. Sample Atmospheric Zone Data Collection Table

0	-3.49	39.85	0.00
50	-110.65	40.53	8.60
100	-217.81	41.22	17.20
200	-637.33	42.58	34.50
300	-637.33	102.93	50.60
400	-835.42	154.14	66.50
500	-1015.02	220.33	80.40
600	-1172.91	294.53	94.10
700	-1344.93	386.45	108.40

800	-1510.05	487.18	124.30
900	-1669.92	597.54	140.00
1000	-1819.59	697.50	155.70
1100	-1962.82	791.55	171.60
1200	-2107.14	882.54	187.30
1300	-2252.08	974.52	200.90
1400	-2401.11	1089.84	216.30
1500	-2557.92	1204.51	233.40
1600	-2713.41	1305.15	247.30
2000	-3432.93	1719.93	309.80
2500	-4463.78	2044.83	385.40
3000	-5456.96	2380.29	460.00
3500	-6199.45	2351.23	531.40
4000	-6717.98	2255.79	603.60
4500	-6878.68	2162.55	676.70
5000	-7034.82	2143.92	749.70
6000	-7071.08	2448.62	892.50
7000	-6320.54	3028.50	1027.80
8000	-5364.19	4235.44	1161.80
9000	-4243.28	6612.17	1332.50

Figure E-4. Sample Atmospheric Zone Data Collection Table (Continued)

E-2. STANDARD ATMOSPHERE (TABLE 2) CONSTRUCTION

The standard atmosphere is a model of pressure, temperature, and RH as a function of altitude. The standard atmosphere table in Table 1 of the MDS represents the region for 15°N latitude (Southeast Asia) and should be used for that region only. To develop a better atmospheric model more representative of your geographic area, Table 2 can be constructed. There are three methods of Table 2 construction, the previous flight method, data transfer method (previous flight data from another section), and the historical archive method.

a. **Previous Flight Method**. To use this method of Table 2 construction, the operator must obtain the atmospheric zone data from a previously run electronic flight. The flight used should be less than 1 hour old. After the model is constructed, the operator then can compare the standard atmosphere table with visual flight (PIBAL) data. The previous flight method is valid except during times of transition and/or when unusual weather patterns develop. The operator extracts the required data from the flight and applies them by using the Table 2 construction steps below.

(1) **Step 1**. Obtain the current raw atmospheric zone data for the previous flight. Obtain a printed copy. See Example 1 for an example of a table.

(2) **Step 2**. Determine maximum altitude for PIBAL flight from mission requirements and current weather conditions.

(3) **Step 3**. After determining maximum altitude, determine the intermediate altitudes by using computer met zone midpoints from Table E-4.

Zone limits (meters)	Zone no.	Midpoint height (meters)	Pressure (mb)	Temperature °C	Temperature °K
Surface.....	00	0	1013	15.0	288.2
0-200.....	01	100	1001	14.4	287.5
200-500.....	02	350	0972	12.7	285.9
500-1,000.....	03	750	0926	10.1	283.3
1,000-1,500.....	04	1,250	0872	6.9	280.0
1,500-2,000.....	05	1,750	0820	3.6	276.8
2,000-2,500.....	06	2,250	0771	0.4	273.5
2,500-3,000.....	07	2,750	0724	-2.9	270.3

3,000-3,500.....	08	3,250	0679	-6.1	267.0
3,400-4,000.....	09	3,750	0637	-9.4	263.8
4,000-4,500.....	10	4,250	0597	-12.6	260.5
4,500-5,000.....	11	4,750	0558	-15.9	257.3
5,000-6,000.....	12	5,500	0505	-20.8	252.4
6,000-7,000.....	13	6,500	0440	-27.3	245.9
7,000-8,000.....	14	7,500	0383	-33.8	239.4
8,000-9,000.....	15	8,500	0331	-40.3	232.9
9,000-10,000.....	16	9,500	0285	-46.8	266.4
10,000-11,000.....	17	10,500	0245	-53.3	219.9
11,000-12,000.....	18	11,500	0209	-56.5	216.7
12,000-13,000.....	19	12,500	0179	-56.5	216.7
13,000-14,000.....	20	13,500	0153	-56.5	216.7
14,000-15,000.....	21	14,500	0130	-56.5	216.7
15,000-16,000.....	22	15,500	0111	-56.5	216.7
16,000-17,000.....	23	16,500	0095	-56.5	216.7
17,000-18,000.....	24	17,500	0081	-56.5	216.7
18,000-19,000.....	25	18,500	0069	-56.5	216.7
19,000-20,000.....	26	19,500	0059	-56.5	216.7

Table E-4. Standard Conditions at Computer Zone Midpoints

(4) **Step 4**. On the page printer record, mark off the maximum height and zone midpoints. If the actual zone midpoint is not listed, choose the closest value to the midpoint. See Example 1.

NOTE: The computer holds only 16 lines of data within Table 2.

(5) **Step 5**. Count the total number of lines (altitudes) selected.

(6) **Step 6**. If there are fewer than 16 lines, determine how many more lines of data you must have to complete the atmospheric model. Use the selection guidelines below to obtain the additional lines.

(a) If a critical temperature change exists (a 1º change or more in column 3), choose those altitudes to be included in the table construction. Underline those lines selected. See Example 2.

(b) If critical temperature changes do not exist, choose altitudes that divide the zones evenly. Underline those lines selected. See Example 2.

NOTE: Since the effects of the lower zones have a major influence on the ballistics of the projectile, the MDS operator must add more altitude measurements for the construction of the table at the lower levels before proceeding to the higher levels.

```
TA
07/20/89/1847   1  214577   5 1016.0  26.0    92  60  10   355    40
    0    1016.00       298.69       301.86       296.36       392.17
   29    1012.62       298.69       301.86       296.30       381.19
   57    1009.31       298.69       301.86       296.23       379.89
   86    1006.06       298.61       301.75       296.08       378.11  ←CLOSEST VALUE TO MIDPOINT
  115    1002.75       298.28       301.41       296.00       377.17
    *          *            *            *            *            *
 4036     631.37       278.09       278.98       271.53       202.28
 4288     612.12       276.50       277.20       268.00       192.06  ←CLOSEST VALUE TO MIDPOINT
 4467     598.75       275.62       276.25       266.02       186.09
 4719     580.44       273.72       274.28       264.25       180.03  ←MAXIMUM ALTITUDE REQUIRED
```

EXAMPLE 1

TA

07/20/89/1847 1 214577 5 1016.0 26.0 92 60 10 355 40

0	1016.00	298.69	301.86	296.36	392.17	←ZONE MIDPOINT[1]
29	1012.62	298.69	301.86	296.30	381.19	
57	1009.31	298.69	301.86	296.23	379.89	
86	1006.06	298.61	301.75	296.08	378.11	←ZONE MIDPOINT[1]
115	1002.75	298.28	301.41	296.00	377.17	
129	1000.02	298.11	301.25	295.89	276.55	
144	999.50	298.00	301.12	295.87	375.91	←EVEN ZONE DIVISION[2]
173	996.25	297.84	300.84	295.72	374.27	
202	992.94	297.59	300.64	295.37	371.47	
308	981.06	296.97	299.91	294.59	364.11	←ZONE MIDPOINT[1]
410	969.75	296.06	298.95	294.20	359.95	
511	958.69	295.05	298.11	294.16	358.12	←TEMP CHANGE OF 1°[2]
512	947.56	294.27	297.09	293.61	353.20	
716	936.37	293.39	296.11	292.89	347.05	←ZONE MIDPOINT[1]
816	925.56	292.53	295.14	292.03	340.31	
918	914.69	291.64	294.12	291.14	333.59	
1012	904.00	291.44	293.92	290.94	329.91	←EVEN ZONE DIVISION[2]
1121	893.50	290.94	293.36	290.45	325.05	
1126	882.56	290.58	292.97	290.08	320.69	←ZONE MIDPOINT[1]
*	*	*	*	*	*	
4467	598.75	275.62	276.25	266.02	186.09	←MAX ALT REQUIRED IS
4719	580.44	273.72	274.28	264.28	180.03	4,700 METERS.[2]
4975	562.25	271.92	272.58	266.05	178.48	

NOTES:
1. Zone midpoints and maximum altitude are required. Do not eliminate them.
2. Always eliminate the higher altitudes first before proceeding to the lower altitudes. (See step 7 on page E-12.)

EXAMPLE 2

(7) **Step 7**. If there are more than 16 lines, eliminate the excessive lines by using the following guidelines:

- First, eliminate the even zone divisions.
- Next, eliminate lines that have a 1° change.

(8) **Step 8**. Once this process is done, recheck the data you have underlined to ensure you have not omitted zone midpoints and critical temperature changes.

(9) **Step 9**. Take the extracted data and place them on the computation work sheet. See Figure E-5 for an example of the computation work sheet.

(10) **Step 10**. Using the computation work sheet, add station height (sta ht) to selected altitude to obtain a corrected altitude (corr alt). Record the results on the work sheet.

NOTE: The operator must extract the following data from the TA table:

- Selected altitude (sel alt) from column 1.

- Pressure (pres) from column 2.
- Temperature (temp) from column 3.
- Dew Point (DP) temperature from column 5. See example 3.

(11) **Step 11**. Using the computation work sheet, determine DP depression. This is done by subtracting DP temperature from the temperature for each line listed on the work sheet. Record the DP depression on the computation work sheet.

DTG _____ REMARKS_____

LINE NUMBER (MDS)	SEL ALT (COL 1 FROM TA TABLE) (1)	STA HT (FROM MAP) (2)	CORR ALT (SEL ALT + STA HT) (3)	PRESS (COL 2 FROM TA TABLE) (4)	TEMP (COL 3 FROM TA TABLE) (5)	TEMP DP (COL 5 FROM TA TABLE) (6)	DEPRESS (TEMP - DP TEMP) (7)	RELATIVE HUMIDITY (FROM RH% TABLE) (8)
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								
13								
14								
15								
16								

Figure E-5. Table 2 Computation Work Sheet Format

TA
07/20/89/1847 1 214577 5 1016.0 26.0 92 60 10 355 40

1. ALT	2. PRESS	3. TEMP	4. VIRTUAL TEMP	5. DP TEMP	6. REFRACTIVITY INDEX	←COLUMN ←COLUMN DESCRIPTION
0	1016.00	298.69	301.86	296.36	392.17	
29	1012.62	298.69	301.86	296.30	381.19	
57	1009.31	298.69	301.86	296.23	379.89	
86	1006.06	298.61	301.75	296.08	378.11	

EXAMPLE 3

NOTE:
1. The previous flight data in the MDS computer does not contain RH values. The standard atmosphere requires a RH value; therefore, the RH percent tables (Tables E-5 through E-9) are provided for ease of conversion. The DP depression and the temperature are used as entry arguments for Tables E-5 through E-9.

2. The operator uses actual temperature, not DP temperature, to enter RH percent table.

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
325	100	99	98	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	75
324	100	99	98	97	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	77	76	75
323	100	99	98	97	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	78	77	76	75
322	100	99	98	97	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	80	79	78	77	76	75
321	100	99	98	97	96	94	93	92	91	90	89	88	87	86	85	84	83	82	82	81	80	79	78	77	76	75
320	100	99	98	97	96	95	93	92	91	90	89	88	87	86	85	84	84	83	82	81	80	79	78	77	77	76
319	100	99	98	97	96	95	94	92	91	90	89	88	88	87	86	84	84	83	82	81	80	79	78	78	77	76
318	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	84	84	83	82	81	80	79	79	78	77	76
317	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	84	84	83	82	81	81	80	79	78	77	76
316	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	84	84	83	82	82	81	80	79	78	77	77
315	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	84	84	83	83	82	81	80	79	78	78	77
314	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	84	84	84	83	82	81	80	79	79	78	77
313	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	86	85	84	83	82	81	80	80	79	78	77
312	100	99	98	97	96	95	94	93	92	91	90	89	88	87	87	86	85	84	83	82	81	81	80	79	78	77
311	100	99	98	97	96	95	94	93	92	91	90	89	88	88	87	86	85	84	83	82	82	81	80	79	78	78
310	100	99	98	97	96	95	94	93	92	91	90	89	89	88	87	86	85	84	83	83	82	81	80	79	79	78
309	100	99	98	97	96	95	94	93	92	91	90	90	89	88	87	86	85	85	84	83	82	81	80	79	79	78
308	100	99	98	97	96	95	94	93	92	91	91	90	89	88	87	86	85	85	84	83	82	81	80	80	79	78
307	100	99	98	97	96	95	94	93	92	92	91	90	89	88	87	86	85	85	84	83	82	81	81	80	79	78
306	100	99	98	97	96	95	94	93	92	92	91	90	89	88	87	86	86	85	84	83	82	82	81	80	79	78
305	100	99	98	97	96	95	94	94	93	92	91	90	89	88	87	87	86	85	84	83	83	82	81	80	79	79
304	100	99	98	97	96	95	94	94	93	92	91	90	89	88	87	87	86	85	84	83	83	82	81	80	80	79
303	100	99	98	97	96	95	94	94	93	92	91	90	89	88	88	87	86	85	84	84	83	82	81	81	80	79
302	100	99	98	97	96	95	95	94	93	92	91	90	89	89	88	87	86	85	85	84	83	82	81	81	80	79
301	100	99	98	97	96	95	95	94	93	92	91	90	89	89	88	87	86	85	85	84	83	82	82	81	80	79
300	100	99	98	97	96	95	95	94	93	92	91	90	90	89	88	87	86	86	85	84	83	82	82	81	80	80
299	100	99	98	97	96	96	95	94	93	92	91	90	90	89	88	87	86	86	85	84	83	83	82	81	80	80
298	100	99	98	97	96	96	95	94	93	92	91	91	90	89	88	87	87	86	85	84	84	83	82	81	81	80
297	100	99	98	97	96	96	95	94	93	92	91	91	90	89	88	87	87	86	85	84	84	83	82	81	81	80
296	100	99	98	97	97	96	95	94	93	92	92	91	90	89	88	88	87	86	85	85	84	83	82	82	81	80
295	100	99	98	97	97	96	95	94	93	92	92	91	90	89	88	88	87	86	85	85	84	83	83	82	81	80
294	100	99	98	97	97	96	95	94	93	92	92	91	90	89	89	88	87	86	86	85	84	83	83	82	81	81
293	100	99	98	97	97	96	95	94	93	93	92	91	90	89	89	88	87	86	86	85	84	84	83	82	81	81
292	100	99	98	97	97	96	95	94	93	93	92	91	90	89	89	88	87	87	86	85	84	84	83	82	82	81
291	100	99	98	97	97	96	95	94	93	93	92	91	90	90	89	88	87	87	86	85	84	84	83	82	82	81
290	100	99	98	98	97	96	95	94	93	93	92	91	90	90	89	88	87	87	86	85	85	84	83	83	82	81
289	100	99	98	98	97	96	95	94	94	93	92	91	91	90	89	88	88	87	86	85	85	84	83	83	82	81
288	100	99	98	98	97	96	95	94	94	93	92	91	91	90	89	88	88	87	86	86	85	84	83	83	82	81
287	100	99	98	98	97	96	95	94	94	93	92	91	91	90	89	88	88	87	86	86	85	84	84	83	82	82
286	100	99	98	98	97	96	95	94	94	93	92	91	91	90	89	89	88	87	86	86	85	84	84	83	82	82
285	100	99	98	98	97	96	95	95	94	93	92	92	91	90	89	89	88	87	87	86	85	85	84	83	83	82
284	100	99	98	98	97	96	95	95	94	93	92	92	91	90	89	89	88	87	87	86	85	85	84	83	83	82
283	100	99	98	98	97	96	95	95	94	93	92	92	91	90	90	89	88	87	87	86	85	85	84	83	83	82
282	100	99	98	98	97	96	95	95	94	93	92	92	91	90	90	89	88	88	87	86	86	85	84	84	83	82
281	100	99	98	98	97	96	95	95	94	93	93	92	91	90	90	89	88	88	87	86	86	85	84	84	83	82
280	100	99	98	98	97	96	95	95	94	93	93	92	91	91	90	89	88	88	87	86	86	85	85	84	83	83

Table E-5. Relative Humidity, Percent (Table 1) Relative humidity, percent-Kelvin temperatures, depression of dew point (Tk - TDk)

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
279	100	99	98	98	97	96	96	95	94	93	93	92	91	91	90	89	89	88	87	87	86	85	85	84	83	83
278	100	99	98	98	97	96	96	95	94	93	93	92	91	91	90	89	89	88	87	87	86	85	85	84	84	83
277	100	99	99	98	97	96	96	95	94	93	93	92	91	91	90	89	89	88	87	87	86	86	85	84	84	83
276	100	99	99	98	97	96	96	95	94	94	93	92	91	91	90	89	89	88	88	87	86	86	85	84	84	83
275	100	99	99	98	97	96	96	95	94	94	93	92	92	91	90	90	89	88	88	87	86	86	85	85	84	83
274	100	99	99	98	97	96	96	95	94	94	93	92	92	91	90	90	89	88	88	87	86	86	85	85	84	83
273	100	99	99	98	97	96	96	95	94	94	93	92	92	91	90	90	89	88	88	87	87	86	85	85	84	84
272	100	99	99	98	97	96	96	95	94	94	93	92	92	91	90	90	89	89	88	87	87	86	85	85	84	84
271	100	99	99	98	97	96	96	95	94	94	93	92	92	91	91	90	89	89	88	87	87	86	86	85	84	84
270	100	99	99	98	97	97	96	95	95	94	93	93	92	91	91	90	89	89	88	87	87	86	86	85	84	84
269	100	99	99	98	97	97	96	95	95	94	93	93	92	91	91	90	89	89	88	88	87	86	86	85	85	84
268	100	99	99	98	97	97	96	95	95	94	93	93	92	91	91	90	90	89	88	88	87	86	86	85	85	84
267	100	99	99	98	97	97	96	95	95	94	93	93	92	91	91	90	90	89	88	88	87	87	86	85	85	84
266	100	99	99	98	97	97	96	95	95	94	93	93	92	92	91	90	90	89	88	88	87	87	86	86	85	84
265	100	99	99	98	97	97	96	95	95	94	93	93	92	92	91	90	90	89	89	88	87	87	86	86	85	85
264	100	99	99	98	97	97	96	95	95	94	94	93	92	92	91	90	90	89	89	88	87	87	86	86	85	85
263	100	99	99	98	97	97	96	95	95	94	94	93	92	92	91	91	90	89	89	88	88	87	86	86	85	85
262	100	99	99	98	97	97	96	95	95	94	94	93	92	92	91	91	90	89	89	88	88	87	87	86	85	85
261	100	99	99	98	97	97	96	96	95	94	94	93	92	92	91	91	90	89	89	88	88	87	87	86	86	85
260	100	99	99	98	97	97	96	96	95	94	94	93	92	92	91	91	90	90	89	88	88	87	87	86	86	85
259	100	99	99	98	97	97	96	96	95	94	94	93	93	92	91	91	90	90	89	88	88	87	87	86	86	85
258	100	99	99	98	97	97	96	96	95	94	94	93	93	92	91	91	90	90	89	89	88	87	87	86	86	85
257	100	99	99	98	97	97	96	96	95	94	94	93	93	92	92	91	90	90	89	89	88	88	87	86	86	85
256	100	99	99	98	98	97	96	96	95	94	94	93	93	92	92	91	90	90	89	89	88	88	87	87	86	85
255	100	99	99	98	98	97	96	96	95	95	94	93	93	92	92	91	90	90	89	89	88	88	87	87	86	86
254	100	99	99	98	98	97	96	96	95	95	94	93	93	92	92	91	91	90	89	89	88	88	87	87	86	86
253	100	99	99	98	98	97	96	96	95	95	94	93	93	92	92	91	91	90	90	89	88	88	87	87	86	86
252	100	99	99	98	98	97	96	96	95	95	94	94	93	92	92	91	91	90	90	89	89	88	87	87	86	86
251	100	99	99	98	98	97	96	96	95	95	94	94	93	92	92	91	91	90	90	89	89	88	88	87	87	86
250	100	99	99	98	98	97	96	96	95	95	94	94	93	92	92	91	91	90	90	89	89	88	88	87	87	86
249	100	99	99	98	98	97	96	96	95	95	94	94	93	93	92	91	91	90	90	89	89	88	88	87	87	86
248	100	99	99	98	98	97	97	96	95	95	94	94	93	93	92	92	91	90	90	89	89	88	88	87	87	86
247	100	99	99	98	98	97	97	96	95	95	94	94	93	93	92	92	91	91	90	89	89	88	88	87	87	86
246	100	99	99	98	98	97	97	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	87	87	86
245	100	99	99	98	98	97	97	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87	87
244	100	99	99	98	98	97	97	96	96	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87	87
243	100	99	99	98	98	97	97	96	96	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87	87
242	100	99	99	98	98	97	97	96	96	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87	87
241	100	99	99	98	98	97	97	96	96	95	95	94	93	93	92	92	91	91	90	90	89	89	88	88	87	87
240	100	99	99	98	98	97	97	96	96	95	95	94	94	93	92	92	91	91	90	90	89	89	88	88	88	87
239	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87
238	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87
237	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87
236	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87
235	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	87
234	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	88	88	88
233	100	99	99	98	98	97	97	96	96	95	95	94	94	93	93	92	92	91	91	90	90	89	89	89	88	88

Table E-5. Relative Humidity, Percent (Table 1) (continued) Relative humidity, percent-Kelvin temperatures, depression of dew point (Tk - TDk)

	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
325	75	74	73	72	71	70	70	69	68	67	66	66	65	64	63	63	62	61	61	60	59	59	58	57	57	56
324	75	74	73	72	71	71	70	69	68	67	67	66	65	64	64	63	62	62	61	60	60	59	58	58	57	56
323	75	74	73	72	72	71	70	69	69	68	67	66	65	65	64	63	63	62	61	61	60	59	59	58	57	57
322	75	74	74	73	72	71	70	70	69	68	67	67	66	65	64	64	63	62	62	61	60	60	59	58	58	57
321	75	75	74	73	72	71	71	70	69	68	68	67	66	65	65	64	63	63	62	61	61	60	59	59	58	57
320	76	75	74	73	72	72	71	70	69	69	68	67	66	66	65	64	64	63	62	62	61	60	60	59	58	58
319	76	75	74	73	73	72	71	70	70	69	68	67	67	66	65	65	64	63	62	62	61	61	60	59	69	68
318	76	75	74	74	73	72	71	71	70	69	68	68	67	66	66	65	64	63	63	62	61	61	60	60	59	58
317	76	76	75	74	73	72	72	71	70	69	69	68	67	66	66	65	64	64	63	62	62	61	61	60	59	59
316	77	76	75	74	73	73	72	71	70	70	59	68	67	67	66	65	65	64	63	63	62	61	61	60	60	59
315	77	76	75	74	74	73	72	71	71	70	69	68	68	67	66	66	65	64	64	63	62	62	61	60	60	59
314	77	76	75	75	74	73	72	72	71	70	69	69	68	67	67	66	65	65	64	63	63	62	61	61	60	60
313	77	76	76	75	74	73	73	72	71	70	70	69	68	68	67	66	66	65	64	64	63	62	62	61	60	60
312	77	77	76	75	74	74	73	72	71	71	70	69	69	68	67	66	66	65	65	64	63	63	62	61	61	60
311	78	77	76	75	74	74	73	72	72	71	70	69	69	68	67	67	66	65	65	64	64	63	62	62	61	61
310	78	77	76	75	75	74	73	73	72	71	70	70	69	68	68	67	66	66	65	64	64	63	63	62	61	61
309	78	77	76	76	75	74	73	73	72	71	71	70	69	69	68	67	67	66	65	65	64	63	63	62	62	61
308	78	77	77	76	75	74	74	73	72	72	71	70	70	69	68	68	67	66	66	65	64	64	63	63	62	61
307	78	78	77	76	75	75	74	73	73	72	71	70	70	69	68	68	67	67	66	65	65	64	63	63	62	62
306	78	78	77	76	76	75	74	73	73	72	71	71	70	69	69	68	67	67	66	66	65	64	64	63	63	62
305	79	78	77	76	76	75	74	74	73	72	72	71	70	70	69	68	68	67	66	66	65	65	64	63	63	62
304	79	78	77	77	76	75	75	74	73	72	72	71	71	70	69	69	68	67	67	66	65	65	64	64	63	63
303	79	78	78	77	76	75	75	74	73	73	72	71	71	70	69	69	68	68	67	66	66	65	65	64	63	63
302	79	78	78	77	76	76	75	74	74	73	72	72	71	70	70	69	68	68	67	67	66	65	65	64	64	63
301	79	79	78	77	77	76	75	74	74	73	73	72	71	71	70	69	69	68	67	67	66	66	65	65	64	63
300	80	79	78	77	77	76	75	75	74	73	73	72	71	71	70	70	69	68	68	67	67	66	65	65	64	64
299	80	79	78	78	77	76	76	75	74	74	73	72	72	71	70	70	69	69	68	67	67	66	66	65	64	64
298	80	79	79	78	77	76	76	75	74	74	73	73	72	71	71	70	69	69	68	68	67	66	66	65	65	64
297	80	79	79	78	77	77	76	75	75	74	73	73	72	71	71	70	70	69	68	68	67	67	66	66	65	64
296	80	80	79	78	77	77	76	76	75	74	74	73	72	72	71	70	70	69	69	68	68	67	66	66	65	65
295	80	80	79	78	78	77	76	76	75	74	74	73	73	72	71	71	70	70	69	68	68	67	67	66	66	65
294	81	80	79	79	78	77	77	76	75	75	74	73	73	72	72	71	70	70	69	69	68	67	67	66	66	65
293	81	80	79	79	78	77	77	76	75	75	74	74	73	72	72	71	71	70	69	69	68	68	67	67	66	65
292	81	80	80	79	78	78	77	76	76	75	74	74	73	73	72	71	71	70	70	69	68	68	67	67	66	66
291	81	80	80	79	78	78	77	76	76	75	75	74	73	73	72	72	71	70	70	69	69	68	68	67	67	66
290	81	81	80	79	79	78	77	77	76	75	75	74	74	73	72	72	71	71	70	70	69	68	68	67	67	66`
289	81	81	80	79	79	78	77	77	76	76	75	74	74	73	73	72	71	71	70	70	69	69	68	68	67	66
288	81	81	80	80	79	78	78	77	76	76	75	75	74	73	73	72	72	71	71	70	69	69	68	68	67	67
287	82	81	80	80	79	78	78	77	77	76	75	75	74	74	73	72	72	71	71	70	70	69	69	68	67	67
286	82	81	80	80	79	79	78	77	77	76	76	75	74	74	73	73	72	72	71	70	70	69	69	68	68	67
285	82	81	81	80	79	79	78	78	77	76	76	75	75	74	73	73	72	72	71	71	70	70	69	68	68	67
284	82	81	81	80	80	79	78	78	77	77	76	75	75	74	74	73	72	72	71	71	70	70	69	69	68	68
283	82	82	81	80	80	79	78	78	77	77	76	76	75	74	74	73	73	72	72	71	71	70	69	69	68	68
282	82	82	81	80	80	79	79	78	77	77	76	76	75	75	74	73	73	72	72	71	71	70	70	69	69	68
281	82	82	81	81	80	79	79	78	78	77	76	76	75	75	74	74	73	73	72	71	71	70	70	69	69	68
280	83	82	81	81	80	80	79	78	78	77	77	76	76	75	74	74	73	73	72	72	71	71	70	70	69	69

Table E-6. Relative Humidity, Percent (Table 2) Relative humidity, percent-Kelvin temperatures, depression of dew point (Tk - TDk)

	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
279	83	82	82	81	80	80	79	79	78	77	77	76	76	75	75	74	73	73	72	72	71	71	70	70	69	69

278	83	82	82	81	80	80	79	79	78	78	77	76	76	75	75	74	74	73	73	72	72	71	71	70	69	69
277	83	82	82	81	81	80	79	79	78	78	77	77	76	75	75	74	74	73	73	72	72	71	71	70	70	69
276	83	83	82	81	81	80	80	79	78	78	77	77	76	76	75	75	74	74	73	72	72	71	71	70	70	69
275	83	83	82	82	81	80	80	79	79	78	77	77	76	76	75	75	74	74	73	73	72	72	71	71	70	70
274	83	83	82	82	81	80	80	79	79	78	78	77	77	76	75	75	74	74	73	73	72	72	71	71	70	70
273	84	83	82	82	81	81	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72	71	71	70
272	84	83	82	82	81	81	80	80	79	79	78	77	77	76	76	75	75	74	74	73	73	72	72	71	71	70
271	84	83	83	82	81	81	80	80	79	79	78	78	77	77	76	75	75	74	74	73	73	72	72	71	71	70
270	84	83	83	82	82	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72	71	71
269	84	83	83	82	82	81	81	80	80	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72	71	71
268	84	84	83	82	82	81	81	80	80	79	79	78	78	77	77	76	75	75	74	74	73	73	73	72	72	71
267	84	84	83	83	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72	71
266	84	84	83	83	82	82	81	81	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72	71
265	85	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72
264	85	84	84	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72	72
263	85	84	84	83	83	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	73	72
262	85	84	84	83	83	82	82	81	81	80	80	79	79	78	77	77	77	76	76	75	75	74	74	73	73	72
261	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73	72
260	85	85	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	74	73	73
259	85	85	84	84	83	83	82	81	81	80	80	79	79	78	78	77	77	77	76	76	75	75	74	74	73	73
258	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73	73
257	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	74	73
256	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	77	76	76	75	75	74	74	73
255	86	85	85	84	84	83	83	82	81	81	81	80	80	79	79	78	78	77	77	76	76	75	75	74	74	73
254	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	75	74	74
253	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	77	76	76	75	75	74	74
252	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	79	78	78	77	77	76	76	75	75	74	74
251	86	85	85	84	84	83	83	82	82	82	81	81	80	80	79	79	78	78	77	77	76	76	75	75	75	74
250	86	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	77	77	77	76	76	75	75	74
249	86	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	79	78	78	77	77	76	76	75	75	75
248	86	86	85	85	84	84	83	83	82	82	81	81	80	80	80	79	79	78	78	77	77	76	76	76	75	75
247	86	86	85	85	84	84	83	83	82	82	82	81	81	80	80	79	79	78	78	77	77	77	76	76	75	75
246	86	86	86	85	85	84	84	83	83	82	82	81	81	80	80	79	79	78	78	78	77	77	76	76	75	75
245	87	86	86	85	85	84	84	83	83	82	82	81	81	80	80	80	79	79	78	78	77	77	76	76	76	75
244	87	86	86	85	85	84	84	83	83	82	82	81	81	81	80	80	79	79	78	78	77	77	77	76	76	75
243	87	86	86	85	85	84	84	83	83	83	82	82	81	81	80	80	79	79	78	78	78	77	77	76	76	75
242	87	86	86	85	85	84	84	84	83	83	82	82	81	81	80	80	79	79	79	78	78	77	77	76	76	76
241	87	86	86	86	85	85	84	84	83	83	82	82	81	81	80	80	80	79	79	78	78	77	77	77	76	76
240	87	87	86	86	85	85	84	84	83	83	82	82	82	81	81	80	80	79	79	78	78	78	77	77	76	76
239	87	87	86	86	85	85	84	84	83	83	83	82	82	81	81	80	80	79	79	79	78	78	77	77	77	76
238	87	87	86	86	85	85	84	84	84	83	83	82	82	81	81	80	80	80	79	79	78	78	77	77	77	76
237	87	87	86	86	85	85	85	84	84	83	83	82	82	81	81	81	80	80	79	79	78	78	78	77	77	76
236	87	87	86	86	86	85	85	84	84	83	83	82	82	82	81	81	80	80	79	79	79	78	78	77	77	77
235	87	87	87	86	86	85	85	84	84	83	83	83	82	82	81	81	80	80	80	79	79	78	78	78	77	77
234	88	87	87	86	86	85	85	84	84	84	83	83	82	82	81	81	81	80	80	79	79	78	78	78	77	77
233	88	87	87	86	86	85	85	85	84	84	83	83	82	82	81	81	81	80	80	79	79	79	78	78	77	77

Table E-6. Relative Humidity, Percent (Table 2) (continued) Relative humidity, percent-Kelvin temperatures; depression of dew point (T_k-TD_k)

	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
325	56	55	55	54	54	53	52	52	51	51	50	49	49	48	48	47	47	46	46	45	45	44	44	43	43	42
324	56	56	55	54	54	53	53	52	52	51	50	50	49	49	48	48	47	47	46	46	45	45	44	44	43	43

323	57	56	55	55	54	54	53	52	52	51	51	50	50	49	49	48	48	47	47	46	46	45	45	44	44	43
322	57	56	56	55	55	54	53	53	52	52	51	51	50	49	49	48	48	47	47	46	46	45	45	44	44	44
321	57	57	56	56	55	54	54	53	53	52	51	51	50	50	49	49	48	48	47	47	46	46	45	45	44	44
320	58	57	56	56	55	55	54	54	53	52	52	51	51	50	50	49	49	48	48	47	47	46	46	45	45	44
319	58	57	57	56	56	55	54	54	53	53	52	52	51	51	50	50	49	48	48	47	47	47	46	46	45	45
318	58	58	57	57	56	55	55	54	54	53	53	52	51	51	50	50	49	49	48	48	47	47	46	46	45	45
317	59	58	57	57	56	56	55	55	54	53	53	52	52	51	51	50	50	49	49	48	48	47	47	46	46	45
316	59	58	58	57	57	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49	48	48	47	47	46	46
315	59	59	58	57	57	56	56	55	55	54	54	53	52	52	51	51	50	50	49	49	48	48	47	47	47	46
314	60	59	58	58	57	57	56	56	55	54	54	53	53	52	52	51	51	50	50	49	49	48	48	47	47	46
313	60	59	59	58	58	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49	48	48	47	47
312	60	60	59	58	58	57	57	56	56	55	55	54	53	53	52	52	51	51	50	50	49	49	49	48	48	47
311	61	60	59	59	58	58	57	57	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49	48	48	47
310	61	60	60	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49	48	48
309	61	61	60	59	59	58	58	57	57	56	56	55	54	54	53	53	52	52	51	51	51	50	50	49	49	48
308	61	61	60	60	59	59	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49	49
307	62	61	61	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50	49	49
306	62	61	61	60	60	59	59	58	58	57	56	56	55	55	54	54	53	53	52	52	52	51	51	50	50	49
305	62	62	61	61	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50	50
304	63	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	50	50
303	63	62	62	61	61	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	52	51	51	50
302	63	63	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51	51	51
301	63	63	62	62	61	61	60	60	59	59	58	57	57	56	56	55	55	55	54	54	53	53	52	52	51	51
300	64	63	63	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	53	52	52	51
299	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	51
298	64	64	63	63	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	55	54	54	53	53	52	52
297	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53	53	52
296	65	64	64	63	63	62	61	61	60	60	59	59	58	58	57	57	57	56	56	55	55	54	54	53	53	52
295	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	55	54	54	53	53
294	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	53
293	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	56	55	55	54	54	53
292	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	55	55	55	54	54
291	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	58	57	57	56	56	55	55	54	54
290	66	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	56	56	56	55	55	54
289	66	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	59	58	58	57	57	56	56	55	55	55
288	67	66	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	57	57	57	56	56	55	55
287	67	66	66	65	65	64	64	63	63	62	62	61	61	60	60	60	59	59	58	58	57	57	56	56	56	55
286	67	67	66	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	58	58	58	57	57	56	56	55
285	67	67	66	66	65	65	64	64	63	63	62	62	61	61	61	60	60	59	59	58	58	57	57	57	56	56
284	68	67	67	66	66	65	65	64	64	63	63	62	62	61	61	60	60	59	59	59	58	58	57	57	56	56
283	68	67	67	66	66	65	65	64	64	63	63	62	62	62	61	61	60	60	59	59	58	58	58	57	57	56
282	68	68	67	67	66	66	65	65	64	64	63	63	62	62	61	61	60	60	60	59	59	58	58	57	57	57
281	68	68	67	67	66	66	65	65	64	64	63	63	63	62	62	61	61	60	60	59	59	59	58	58	57	57
280	69	68	68	67	67	66	66	65	65	64	64	63	63	62	62	61	61	61	60	60	59	59	58	58	58	57

Table E-7. Relative Humidity, Percent (Table 3) Relative humidity, percent-Kelvin temperatures; depression of dew point (T_k-TD_k)

	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
279	69	68	68	67	67	66	66	65	65	64	64	63	63	63	62	62	61	61	60	60	59	59	59	58	58	57
278	69	68	68	68	67	67	66	66	65	65	64	64	63	63	62	62	61	61	61	60	60	59	59	58	58	58

277	69	69	68	68	67	67	66	66	65	65	64	64	63	63	63	62	62	61	61	60	60	60	59	59	58	58
276	69	69	68	68	67	67	67	66	66	65	65	64	64	63	63	62	62	62	61	61	60	60	59	59	59	58
275	70	69	69	68	68	67	67	66	66	65	65	64	64	64	63	63	62	62	61	61	61	60	60	59	59	58
274	70	69	69	68	68	67	67	67	66	66	65	65	64	64	63	63	62	62	62	61	61	60	60	60	59	59
273	70	70	69	69	68	68	67	67	66	66	65	65	64	64	64	63	63	62	62	61	61	61	60	60	59	59
272	70	70	69	69	68	68	67	67	66	66	66	65	65	64	64	63	63	63	62	62	61	61	60	60	60	59
271	70	70	70	69	69	68	68	67	67	66	66	65	65	64	64	64	63	63	62	62	62	61	61	60	60	59
270	71	70	70	69	69	68	68	67	67	66	66	66	65	65	64	64	63	63	63	62	62	61	61	61	60	60
269	71	70	70	69	69	69	68	68	67	67	66	66	65	65	65	64	64	63	63	62	62	62	61	61	60	60
268	71	71	70	70	69	69	68	68	67	67	66	66	66	65	65	64	64	63	63	63	62	62	61	61	61	60
267	71	71	70	70	69	69	68	68	68	67	67	66	66	65	65	65	64	64	63	63	62	62	62	61	61	60
266	71	71	71	70	70	69	69	68	68	67	67	66	66	66	65	65	64	64	64	63	63	62	62	62	61	61
265	72	71	71	70	70	69	69	68	68	68	67	67	66	66	65	65	65	64	64	63	63	63	62	62	61	61
264	72	71	71	70	70	70	69	69	68	68	67	67	66	66	66	65	65	64	64	64	63	63	62	62	62	61
263	72	72	71	71	70	70	69	69	68	68	68	67	67	66	66	65	65	65	64	64	63	63	63	62	62	61
262	72	72	71	71	70	70	70	69	69	68	68	67	67	67	66	66	65	65	64	64	64	63	63	62	62	62
261	72	72	72	71	71	70	70	69	69	68	68	68	67	67	66	66	65	65	65	64	64	63	63	63	62	62
260	73	72	72	71	71	70	70	69	69	69	68	68	67	67	67	66	66	65	65	64	64	64	63	63	63	62
259	73	72	72	71	71	71	70	70	69	69	68	68	68	67	67	66	66	66	65	65	64	64	64	63	63	62
258	73	73	72	72	71	71	70	70	69	69	69	68	68	67	67	66	66	66	65	65	65	64	64	63	63	63
257	73	73	72	72	71	71	71	70	70	69	69	68	68	68	67	67	66	66	66	65	65	64	64	64	63	63
256	73	73	72	72	72	71	71	70	70	69	69	69	68	68	67	67	67	66	66	65	65	65	64	64	63	63
255	73	73	73	72	72	71	71	70	70	70	69	69	68	68	68	67	67	66	66	66	65	65	64	64	64	63
254	74	73	73	72	72	71	71	71	70	70	69	69	69	68	68	67	67	67	66	66	65	65	65	64	64	64
253	74	73	73	73	72	72	71	71	70	70	70	69	69	68	68	68	67	67	66	66	66	65	65	64	64	64
252	74	74	73	73	72	72	71	71	71	70	70	69	69	69	68	68	67	67	67	66	66	65	65	65	64	64
251	74	74	73	73	72	72	72	71	71	70	70	70	69	69	68	68	68	67	67	66	66	66	65	65	65	64
250	74	74	73	73	73	72	72	71	71	71	70	70	69	69	69	68	68	67	67	67	66	66	65	65	65	64
249	75	74	74	73	73	72	72	72	71	71	70	70	70	69	69	68	68	68	67	67	66	66	66	65	65	65
248	75	74	74	73	73	73	72	72	71	71	71	70	70	69	69	69	68	68	67	67	67	66	66	66	65	65
247	75	74	74	74	73	73	72	72	72	71	71	70	70	70	69	69	68	68	68	67	67	66	66	66	65	65
246	75	75	74	74	73	73	73	72	72	71	71	71	70	70	69	69	69	68	68	67	67	67	66	66	66	65
245	75	75	74	74	74	73	73	72	72	71	71	71	70	70	70	69	69	68	68	68	67	67	67	66	66	65
244	75	75	74	74	74	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	67	67	67	66	66	66
243	75	75	75	74	74	73	73	73	72	72	71	71	71	70	70	70	69	69	68	68	68	67	67	67	66	66
242	76	75	75	74	74	74	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	67	67	67	66	66
241	76	75	75	75	74	74	73	73	73	72	72	71	71	71	70	70	70	69	69	68	68	68	67	67	67	66
240	76	76	75	75	74	74	74	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	68	67	67	66
239	76	76	75	75	74	74	74	73	73	73	72	72	71	71	71	70	70	70	69	69	68	68	68	67	67	67
238	76	76	75	75	75	74	74	73	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	68	67	67
237	76	76	76	75	75	74	74	74	73	73	72	72	72	71	71	71	70	70	70	69	69	68	68	68	67	67
236	77	76	76	75	75	75	74	74	73	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	68	67
235	77	76	76	76	75	75	74	74	74	73	73	72	72	72	71	71	71	70	70	70	69	69	68	68	68	67
234	77	76	76	76	75	75	75	74	74	73	73	73	72	72	72	71	71	70	70	70	69	69	69	68	68	68
233	77	77	76	76	75	75	75	74	74	74	73	73	72	72	72	71	71	71	70	70	70	69	69	68	68	68

Table E-7. Relative Humidity, Percent (Table 3) (continued) Relative humidity, percent-Kelvin temperatures; depression of dew point (T_k-TD_k)

	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0
325	42	42	41	41	41	40	40	39	39	38	38	38	37	37	36	36	36	35	35	34	34	34	33	33	33	32
324	43	42	42	41	41	40	40	40	39	39	38	38	38	37	37	36	36	36	35	35	34	34	34	33	33	33
323	43	43	42	42	41	41	40	40	40	39	39	38	38	38	37	37	36	36	36	35	35	34	34	34	33	33

322	44	43	43	42	42	41	41	40	40	40	39	39	38	38	38	37	37	36	36	36	35	35	34	34	34	33
321	44	43	43	43	42	42	41	41	40	40	40	39	39	38	38	37	37	37	36	36	36	35	35	35	34	34
320	44	44	43	43	42	42	42	41	41	40	40	39	39	39	38	38	37	37	37	36	36	36	35	35	35	34
319	45	44	44	43	43	42	42	42	41	41	40	40	39	39	39	38	38	37	37	37	36	36	36	35	35	35
318	45	45	44	44	43	43	42	42	41	41	41	40	40	39	39	39	38	38	37	37	37	36	36	36	35	35
317	45	45	44	44	44	43	43	42	42	41	41	41	40	40	39	39	39	38	38	37	37	37	36	36	36	35
316	46	45	45	44	44	43	43	43	42	42	41	41	41	40	40	39	39	39	38	38	37	37	37	36	36	36
315	46	46	45	45	44	44	43	43	43	42	42	41	41	41	40	40	39	39	39	38	38	37	37	37	36	36
314	46	46	46	45	45	44	44	43	43	43	42	42	41	41	40	40	40	39	39	39	38	38	37	37	37	36
313	47	46	46	45	45	45	44	44	43	43	42	42	42	41	41	40	40	40	39	39	39	38	38	37	37	37
312	47	47	46	46	45	45	44	44	44	43	43	42	42	42	41	41	40	40	40	39	39	39	38	38	37	37
311	47	47	47	46	46	45	45	44	44	44	43	43	42	42	42	41	41	40	40	40	39	39	39	38	38	37
310	48	47	47	46	46	46	45	45	44	44	44	43	43	42	42	42	41	41	40	40	40	39	39	39	38	38
309	48	48	47	47	46	46	46	45	45	44	44	43	43	43	42	42	42	41	41	40	40	40	39	39	39	38
308	49	48	48	47	47	46	46	45	45	45	44	44	43	43	43	42	42	41	41	41	40	40	40	39	39	39
307	49	48	48	48	47	47	46	46	45	45	45	44	44	43	43	43	42	42	41	41	41	40	40	40	39	39
306	49	49	48	48	47	47	47	46	46	45	45	45	44	44	43	43	43	42	42	41	41	41	40	40	40	39
305	50	49	49	48	48	47	47	47	46	46	45	45	44	44	44	43	43	43	42	42	41	41	41	40	40	40
304	50	49	49	49	48	48	47	47	46	46	46	45	45	44	44	44	43	43	43	42	42	41	41	41	40	40
303	50	50	49	49	48	48	48	47	47	46	46	46	45	45	44	44	44	43	43	42	42	42	41	41	41	40
302	51	50	50	49	49	48	48	48	47	47	46	46	45	45	45	44	44	44	43	43	42	42	42	41	41	41
301	51	50	50	50	49	49	48	48	47	47	47	46	46	45	45	45	44	44	44	43	43	42	42	42	41	41
300	51	51	50	50	49	49	49	48	48	47	47	47	46	46	45	45	45	44	44	43	43	43	42	42	42	41
299	51	51	51	50	50	49	49	49	48	48	47	47	46	46	46	45	45	45	44	44	43	43	43	42	42	42
298	52	51	51	51	50	50	49	49	48	48	48	47	47	46	46	46	45	45	45	44	44	43	43	43	42	42
297	52	52	51	51	50	50	50	49	49	48	48	48	47	47	46	46	46	45	45	44	44	44	43	43	43	42
296	52	52	52	51	51	50	50	49	49	49	48	48	47	47	47	46	46	46	45	45	44	44	44	43	43	43
295	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	47	46	46	46	45	45	44	44	44	43	43
294	53	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	47	46	46	45	45	45	44	44	44	43
293	53	53	52	52	52	51	51	50	50	50	49	49	48	48	48	47	47	47	46	46	45	45	45	44	44	44
292	54	53	53	52	52	52	51	51	50	50	50	49	49	48	48	48	47	47	46	46	46	45	45	45	44	44
291	54	54	53	53	52	52	51	51	51	50	50	49	49	49	48	48	48	47	47	46	46	46	45	45	45	44
290	54	54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	47	46	46	46	45	45	45
289	55	54	54	53	53	52	52	52	51	51	50	50	50	49	49	49	48	48	47	47	47	46	46	46	45	45
288	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49	49	48	48	48	47	47	47	46	46	46	45
287	55	55	54	54	53	53	53	52	52	51	51	51	50	50	50	49	49	48	48	48	47	47	47	46	46	46
286	55	55	55	54	54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48	48	47	47	47	46	46
285	56	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	49	49	49	48	48	48	47	47	47	46
284	56	56	55	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49	49	49	48	48	48	47	47	47
283	56	56	55	55	55	54	54	53	53	53	52	52	51	51	51	50	50	50	49	49	49	48	48	48	47	47
282	57	56	56	55	55	55	54	54	53	53	53	52	52	51	51	51	50	50	50	49	49	49	48	48	47	47
281	57	56	56	56	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	50	49	49	48	48	48	47
280	57	57	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	49	49	49	48	48	48

Table E-8. Relative Humidity, Percent (Table 4) Relative humidity, percent-Kelvin temperatures, depression of dew point (Tk - TDk)

	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0
279	57	57	57	56	56	55	55	55	54	54	53	53	53	52	52	52	51	51	50	50	50	49	49	49	48	48
278	58	57	57	56	56	56	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50	50	49	49	49	48
277	58	57	57	57	56	56	56	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	50	49	49	49
276	58	58	57	57	57	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	50	49	49

275	58	58	58	57	57	56	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	51	50	50	50	49
274	59	58	58	57	57	57	56	56	56	55	55	54	54	54	53	53	53	52	52	52	51	51	51	50	50	49
273	59	59	58	58	57	57	57	56	56	55	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50	50
272	59	59	58	58	58	57	57	56	56	56	55	55	55	54	54	53	53	53	52	52	52	51	51	51	50	50
271	59	59	59	58	58	58	57	57	56	56	56	55	55	55	54	54	53	53	53	52	52	52	51	51	51	50
270	60	59	59	59	58	58	57	57	57	56	56	56	55	55	54	54	54	53	53	53	52	52	52	51	51	51
269	60	60	59	59	58	58	58	57	57	57	56	56	55	55	55	54	54	54	53	53	53	52	52	52	51	51
268	60	60	59	59	59	58	58	58	57	57	56	56	56	55	55	55	54	54	54	53	53	53	52	52	52	51
267	60	60	60	59	59	59	58	58	57	57	57	56	56	56	55	55	55	54	54	53	53	53	52	52	52	51
266	61	60	60	60	59	59	58	58	58	57	57	57	56	56	55	55	55	54	54	54	53	53	53	52	52	52
265	61	61	60	60	59	59	59	58	58	58	57	57	56	56	56	55	55	55	54	54	54	53	53	53	52	52
264	61	61	60	60	60	59	59	59	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53	53	52
263	61	61	61	60	60	60	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53	53
262	62	61	61	61	60	60	59	59	59	58	58	58	57	57	57	56	56	55	55	55	54	54	54	53	53	53
261	62	62	61	61	60	60	60	59	59	59	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53
260	62	62	61	61	61	60	60	60	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53
259	62	62	62	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54
258	63	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54
257	63	62	62	62	61	61	61	60	60	60	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54
256	63	63	62	62	62	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54
255	63	63	63	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55
254	64	63	63	62	62	62	61	61	61	60	60	60	59	59	58	58	58	57	57	57	57	56	56	56	55	55
253	64	63	63	63	62	62	62	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55	55
252	64	64	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56	55
251	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56	56
250	64	64	64	63	63	63	62	62	62	61	61	60	60	60	59	59	59	58	58	58	57	57	57	57	56	56
249	65	64	64	64	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56	56
248	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57	56
247	65	65	64	64	64	63	63	63	62	62	61	61	61	60	60	60	59	59	59	59	58	58	58	57	57	57
246	65	65	65	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57	57
245	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	57	57
244	66	65	65	65	64	64	64	63	63	62	62	62	61	61	61	61	60	60	60	59	59	59	58	58	58	57
243	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58	58
242	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58	58	58
241	66	66	66	65	65	64	64	64	63	63	63	62	62	62	61	61	61	61	60	60	60	59	59	59	58	58
240	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	59	58
239	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59	59	58
238	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	61	60	60	60	59	59	59
237	67	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	60	59	59
236	67	67	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60	59	59
235	67	67	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	62	61	61	61	60	60	60	59
234	68	67	67	67	66	66	66	65	65	65	64	64	64	63	63	63	62	62	62	61	61	61	61	60	60	60
233	68	67	67	67	66	66	66	65	65	65	64	64	64	64	63	63	63	62	62	62	61	61	61	60	60	60

Table E-8. Relative Humidity, Percent (Table 4) (continued) Relative humidity, percent-Kelvin temperatures; depression of dew point (T_k - TD_k)

	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
325	32	31	29	28	26	25	24	22	21	20	19	18	17	16	16	15	14	13	13	12	12
324	33	31	29	28	26	25	24	23	22	20	19	19	18	17	16	15	14	14	13	12	12
323	33	31	30	28	27	25	24	23	22	21	20	19	18	17	16	15	15	14	13	13	12
322	33	32	30	29	27	26	25	23	22	21	20	19	18	17	17	16	15	14	14	13	12
321	34	32	31	29	28	26	25	24	23	21	20	19	19	18	17	16	15	15	14	13	13
320	34	32	31	29	28	27	25	24	23	22	21	20	19	18	17	16	16	15	14	14	13
319	35	33	31	30	28	27	26	24	23	22	21	20	19	18	17	17	16	15	14	14	13
318	35	33	32	30	29	27	26	25	24	22	21	20	20	19	18	17	16	15	15	14	13
317	35	34	32	30	29	28	26	25	24	23	22	21	20	19	18	17	16	16	15	14	14
316	36	34	32	31	29	28	27	25	24	23	22	21	20	19	18	18	17	16	15	15	14
315	36	34	33	31	30	28	27	26	25	24	22	21	20	20	19	18	17	16	16	15	14
314	36	35	33	32	30	29	27	26	25	24	23	22	21	20	19	18	17	17	16	15	15
313	37	35	33	32	30	29	28	26	25	24	23	22	21	20	19	18	18	17	16	15	15
312	37	35	34	32	31	29	28	27	26	25	23	22	21	20	20	19	18	17	16	16	15
311	37	36	34	33	31	30	28	27	26	25	24	23	22	21	20	19	18	17	17	16	15
310	38	36	35	33	32	30	29	28	26	25	24	23	22	21	20	19	19	18	17	16	16
309	38	37	35	33	32	30	29	28	27	26	24	23	22	22	21	20	19	18	17	17	16
308	39	37	35	34	32	31	29	28	27	26	25	24	23	22	21	20	19	18	18	17	16
307	39	37	36	34	33	31	30	29	27	26	25	24	23	22	21	20	19	19	18	17	16
306	39	38	36	34	33	32	30	29	28	27	25	24	23	22	21	21	20	19	18	17	17
305	40	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	18	18	17
304	40	38	37	35	34	32	31	30	28	27	26	25	24	23	22	21	20	20	19	18	17
303	40	39	37	35	34	33	31	30	29	28	26	25	24	23	22	22	21	20	19	18	18
302	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22	21	20	19	19	18
301	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	20	19	18
300	41	40	38	36	35	34	32	31	30	29	27	26	25	24	23	22	22	21	20	19	18
299	42	40	38	37	35	34	33	31	30	29	28	27	26	25	24	23	22	21	20	19	19
298	42	40	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22	21	21	20	19
297	42	41	39	37	36	35	33	32	31	29	28	27	26	25	24	23	22	22	21	20	19
296	43	41	39	38	36	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	20
295	43	41	40	38	37	35	34	33	31	30	29	28	27	26	25	24	23	22	21	21	20
294	43	42	40	38	37	36	34	33	32	30	29	28	27	26	25	24	23	23	22	21	20
293	44	42	40	39	37	36	35	33	32	31	30	29	27	27	25	25	24	23	22	21	20
292	44	42	41	39	38	36	35	34	32	31	30	29	28	27	26	25	24	23	22	21	21
291	44	43	41	39	38	37	35	34	33	31	30	29	28	27	26	25	24	23	23	22	21
290	45	43	41	40	38	37	36	34	33	32	31	29	28	27	26	25	25	24	23	22	21
289	45	43	42	40	39	37	36	35	33	32	31	30	29	28	27	26	25	24	23	22	22
288	45	44	42	40	39	38	36	35	34	32	31	30	29	28	27	26	25	24	23	23	22
287	46	44	42	41	39	38	36	35	34	33	32	30	29	28	27	26	25	25	24	23	22
286	46	44	43	41	40	38	37	35	34	33	32	31	30	29	28	27	26	25	24	23	22
285	46	45	43	41	40	38	37	36	35	33	32	31	30	29	28	27	26	25	24	24	23
284	47	45	43	42	40	39	37	36	35	34	32	31	30	29	28	27	26	25	25	24	23
283	47	45	44	42	41	39	38	36	35	34	33	32	31	30	29	28	27	26	25	24	23
282	47	45	44	42	41	39	38	37	35	34	33	32	31	30	29	28	27	26	25	24	24
281	47	46	44	43	41	40	38	37	36	35	33	32	31	30	29	28	27	26	26	25	24
280	48	46	44	43	41	40	39	37	36	35	34	33	32	30	29	29	28	27	26	25	24

Table E-9. Relative Humidity, Percent (Table 5) Relative humidity, percent-Kelvin temperatures, depression of dew point (Tk - Tdk)

	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
279	48	46	45	43	42	40	39	38	36	35	34	33	32	31	30	29	28	27	26	25	24
278	48	47	45	44	42	41	39	38	37	36	34	33	32	31	30	29	28	27	26	26	25
277	49	47	45	44	42	41	40	38	37	36	35	34	32	31	30	29	28	28	27	26	25
276	49	47	46	44	43	41	40	39	37	36	35	34	33	32	31	30	29	28	27	26	25
275	49	48	46	44	43	42	40	39	38	36	35	34	33	32	31	30	29	28	27	26	26
274	49	48	46	45	43	42	41	39	38	37	36	34	33	32	31	30	29	28	28	27	26
273	50	48	47	45	44	42	41	40	38	37	36	35	34	33	32	31	30	29	28	27	26
272	50	48	47	45	44	42	41	40	39	37	36	35	34	33	32	31	30	29	28	27	26
271	50	49	47	46	44	43	41	40	39	38	36	35	34	33	32	31	30	29	28	28	27
270	51	49	47	46	44	43	42	40	39	38	37	36	35	33	32	31	31	30	29	28	27
269	51	49	48	46	45	43	42	41	39	38	37	36	35	34	33	32	31	30	29	28	27
268	51	50	48	47	45	43	42	41	40	39	37	36	35	34	33	32	31	30	29	28	28
267	51	50	48	47	45	44	43	41	40	39	38	37	35	34	33	32	31	30	30	29	28
266	52	50	49	47	46	44	43	42	40	39	38	37	36	35	34	33	32	31	30	29	28
265	52	50	49	47	46	45	43	42	41	39	38	37	36	35	34	33	32	31	30	29	28
264	52	51	49	48	46	45	43	42	41	40	39	37	36	35	34	33	32	31	30	30	29
263	53	51	49	48	46	45	44	42	41	40	39	38	37	36	34	33	33	32	31	30	29
262	53	51	50	48	47	45	44	43	41	40	39	38	37	36	35	34	33	32	31	30	29
261	53	52	50	48	47	46	44	43	42	41	39	38	37	36	35	34	33	32	31	30	30
260	53	52	50	49	47	46	45	43	42	41	40	39	37	36	35	34	33	32	32	31	30
259	54	52	51	49	48	46	45	44	42	41	40	39	38	37	36	35	34	33	32	31	30
258	54	53	51	49	48	46	45	44	43	41	40	39	38	37	36	35	34	33	32	31	30
257	54	53	51	50	48	47	45	44	43	42	41	39	38	37	36	35	34	33	32	32	31
256	54	53	51	50	48	47	46	44	43	42	41	40	39	38	36	35	35	34	33	32	31
255	55	53	52	50	49	47	46	45	43	42	41	40	39	38	37	36	35	34	33	32	31
254	55	53	52	50	49	48	46	45	44	43	41	40	39	38	37	36	35	34	33	32	31
253	55	54	52	51	49	48	47	45	44	43	42	40	39	38	37	36	35	34	33	33	32
252	55	54	52	51	49	48	47	46	44	43	42	41	40	39	38	37	36	35	34	33	32
251	56	54	53	51	50	48	47	46	45	43	42	41	40	39	38	37	36	35	34	33	32
250	56	54	53	51	50	49	47	46	45	44	42	41	40	39	38	37	36	35	34	33	33
249	56	55	53	52	50	49	48	46	45	44	43	42	40	39	38	37	36	35	35	34	33
248	56	55	53	52	51	49	48	47	45	44	43	42	41	40	39	38	37	36	35	34	33
247	57	55	54	52	51	49	48	47	46	44	43	42	41	40	39	38	37	36	35	34	33
246	57	55	54	52	51	50	48	47	46	45	44	42	41	40	39	38	37	36	35	35	34
245	57	56	54	53	51	50	49	47	46	45	44	43	42	41	39	38	38	37	36	35	34
244	57	56	54	53	52	50	49	48	46	45	44	43	42	41	40	39	38	37	36	35	34
243	58	56	55	53	52	50	49	48	47	45	44	43	42	41	40	39	38	37	36	35	34
242	58	56	55	53	52	51	49	48	47	46	45	43	42	41	40	39	38	37	36	36	35
241	58	57	55	54	52	51	50	48	47	46	45	44	43	42	41	40	39	38	37	36	35
240	58	57	55	54	53	51	50	49	47	46	45	44	43	42	41	40	39	38	37	36	35
239	58	57	56	54	53	51	50	49	48	47	45	44	43	42	41	40	39	38	37	36	35
238	59	57	56	54	53	52	50	49	48	47	46	45	43	42	41	40	39	38	38	37	36
237	59	57	56	55	53	52	51	49	48	47	46	45	44	43	42	41	40	39	38	37	36
236	59	58	56	55	53	52	51	50	48	47	46	45	44	43	42	41	40	39	38	37	36
235	59	58	56	55	54	52	51	50	49	48	46	45	44	43	42	41	40	39	38	37	37
234	60	58	57	55	54	53	51	50	49	48	47	46	44	43	42	41	40	39	39	38	37
233	60	58	57	56	54	53	52	50	49	48	47	46	45	44	43	42	41	40	39	38	37

Table E-9. Relative Humidity, Percent (Table 5) (continued) Relative humidity, percent-Kelvin temperatures; depression of dew point (T_k - TD_k)

(12) **Step 12**. Locate the temperature value on the left side of the RH percent table. See Example 4.

(13) **Step 13**. Locate the DP depression on top (horizontal column) of the RH percent table. See Example 4.

(14) **Step 14**. Using the RH percent table, determine the relative humidity by following across the temperature line until you reach the depression column.

(15) **Step 15**. Extract the value for the humidity from the RH percent table. Place the humidity value on the computation work sheet.

NOTE:
1. If the temperature and/or the DP depression does not exist, use the nearest value. Interpolation is not required.

2. If the DP depression is in excess of 20.0 but less than 22.5, use the value for 20.0.

3. If the DP depression is above 22.5, subtract 1 percent from the RH value listed in column 20.0.

(16) **Step 16**. Construct Table 2. Follow the procedures outlined in TM 11-6660-265-10/1.

NOTE: The required data to be entered into Table 2 are located on the computation work sheet. They are the corrected altitude from column 3, pressure from column 4, temperature from column 5, and relative humidity from column 8.

b. **Historical Archive Method**. The historical archive method uses data from previous years to develop an average model for the operating area. This model of the atmosphere is developed by using the average pressure, temperature, and RH over a 3-year period for a given month of operation. By averaging out the extremes, a general model is developed for the region. This method reduces the need to conduct electronic flights on a daily basis. However, this method is not valid during unusual weather conditions. Therefore, electronic flights will be required.

(1) If a met section has 3 or more years of historical data on file for the area of operation, the operator can develop a standard atmosphere model by using the historical archive method. If a met section does not have 3 years of historical data, the operator must use another method to construct the table.

Table 5
Relative Humidity, percent-Kelvin temperatures Depression of Dew Point

	10.0	10.5	11.0	12.0	19.5	20.0	←DP DEPESSION
325	32	31	29	26	12	12	
324	33	31	29	26	12	12	
323	33	31	30	27	13	12	←% RH
322	33	32	30	27	13	12	
321	34	32	31	28	13	13	

↑
ACTUAL TEMP

EXAMPLE 4

(2) Previous recorded data either from the MDS or MMS can be used to construct the table. After the table has been constructed, the operator should verify the results obtained and check for inaccuracies with the annual standards table produced by the Atmospheric Science Laboratory (ASL) and Ballistic Research Laboratory (BRL).

(3) The steps for constructing the standard atmosphere table by using the historical archive method are discussed below.

(a) Step 1. Obtain the required raw data for each zone over the 3 previous years for the same time of year (day and month) for the operating area.

NOTE: The zone midpoint data are required for each day for each year. These data will include the midpoint altitude, pressure, temperature, and RH or DP temperature for each zone for the 3 years.

(b) Step 2. Average each zone level pressure for each day for the last 3 years. Record the averages (see Example 5) on the computation work sheet.

(c) Step 3. Repeat step 2 for the temperature and RH (or DP temperature). Record the results on the computation work sheet.

NOTE: If the operator must obtain relative humidity from the DP temperature, use steps 11 through 15 in paragraph E-2 to compute the relative humidity.

(d) Step 4. Compare the average data obtained for each zone for the current month with data from the same month of previous years for seasonal variations.

NOTE:

1. The tolerances for the data are as follows:
   - Pressure - + or - 10 mb
   - Temperature - + or - 10 mb
   - Humidity - + or - 2 percent

2. The process in step 4 alerts the operator if an unseasonable or extreme weather pattern exists in his operating area.

3. Always update met computations every year with new data. The more years the operator uses in the averaging, the better the atmospheric model will be.

Averaging the data (for 21 July 1990)

LINE	YEAR	PRESSURE	TEMPERATURE	RELATIVE HUMIDITY
	87	972.10	295.10	56
01	88	972.90	295.80	65
	89	973.20	297.10	67
Average	90	972.73	296.00	62
Year 1 + year 2 + year 3 = (subtotal) ÷ 3 = average				

EXAMPLE 5

(e) Step 5. Repeat steps 2 through 4 for each zone required.

(f) Step 6. Edit Table 2 with data from the computation work sheet. The procedures are outlined in TM 11-6660-265-10/1.

c. **Data Transfer Method**. When one met section is unable to conduct flights and another met section is located in the same operating area, one section can transfer met data to another. This method is used to transfer the data needed to construct Table 2. After met data are transferred, the operator can construct Table 2 by using the procedures in paragraph a for the previous flight method. However, it should be noted that the varying terrain has an effect on the validity of met information produced.

Appendix F
NAVAID Coverage Charts and Tables

This appendix provides charts for the selection of optimum coverages. Section I contains an overview of the long-range aid to navigation coverage charts. Section II contains a map depicting very low frequency and Omega station locations. Apply the procedures outlined in Chapter 4 to enter the charts in this appendix.

Section I
LORAN Coverage Charts

F-1. LORAN STATUS

The US Department of Defense requirement for foreign LORAN-C coverage ended December 31, 1994. The Coast Guard has either closed or turned over the foreign stations to the host country. As a result predictability of coverage availability is no longer possible. Some chains no longer have the requisite three stations operating, while other are completely off the air. Met personnel should consult with local authorities when selecting optimum LORAN-C coverage. Those chains operational as of the publication date are contained in Section I. Table F-1 is a quick reference for the LORAN chains' master and secondary stations. See Figures F-1 through F-14 for the specific master and secondary stations for each chain.

CHAIN NAME	MASTER STATIONS	SECONDARY STATIONS
Canadian East Coast Chain	M	X, Y, Z
Commando Lion Chain	M	W, X, Y
Canadian West Coast Chain	M	X, Y, Z
South Saudi Arabia Chain	M	W, X, Y, Z
Gulf of Alaska Chain	M	X, Y
Southeast United States Chain	M	W, X, Y, Z
Mediterranean Chain	M	X, Y, Z
Great Lakes Chain	M	W, X, Y
North Saudi Arabia Chain	M	V, W, X, Y, Z
United States West Coast Chain	M	W. X. Y
Northeast United States Chain	M	W, X, Y, Z
North Pacific Chain	M	X, Y, Z
North Central United States Chain	M	W, X, Y
South Central United States Chain	M	V, W, X, Y, Z

Table F-1. LORAN Chains' Stations

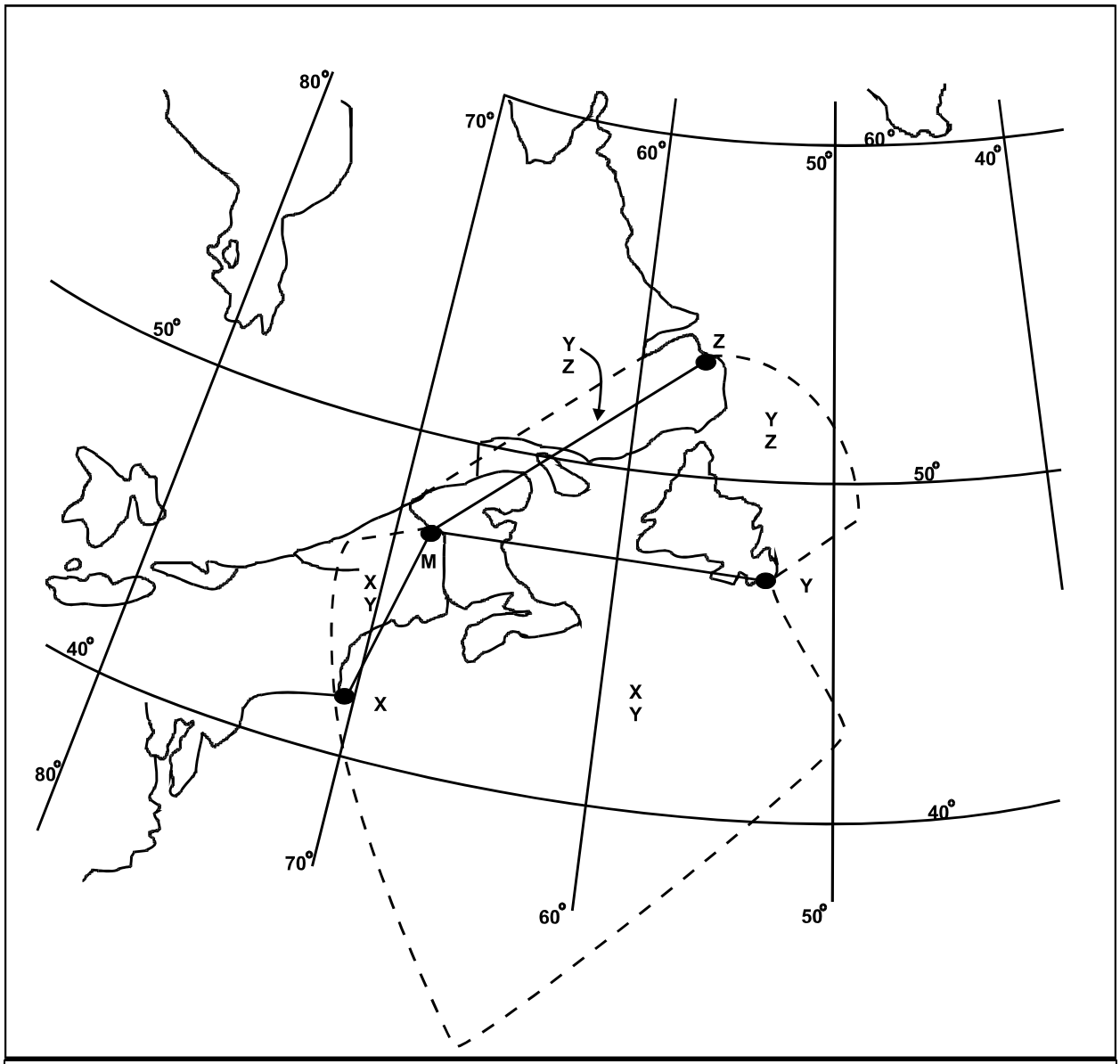


Figure F-1. LORAN-C, Canadian East Coast Chain, GRI 5930

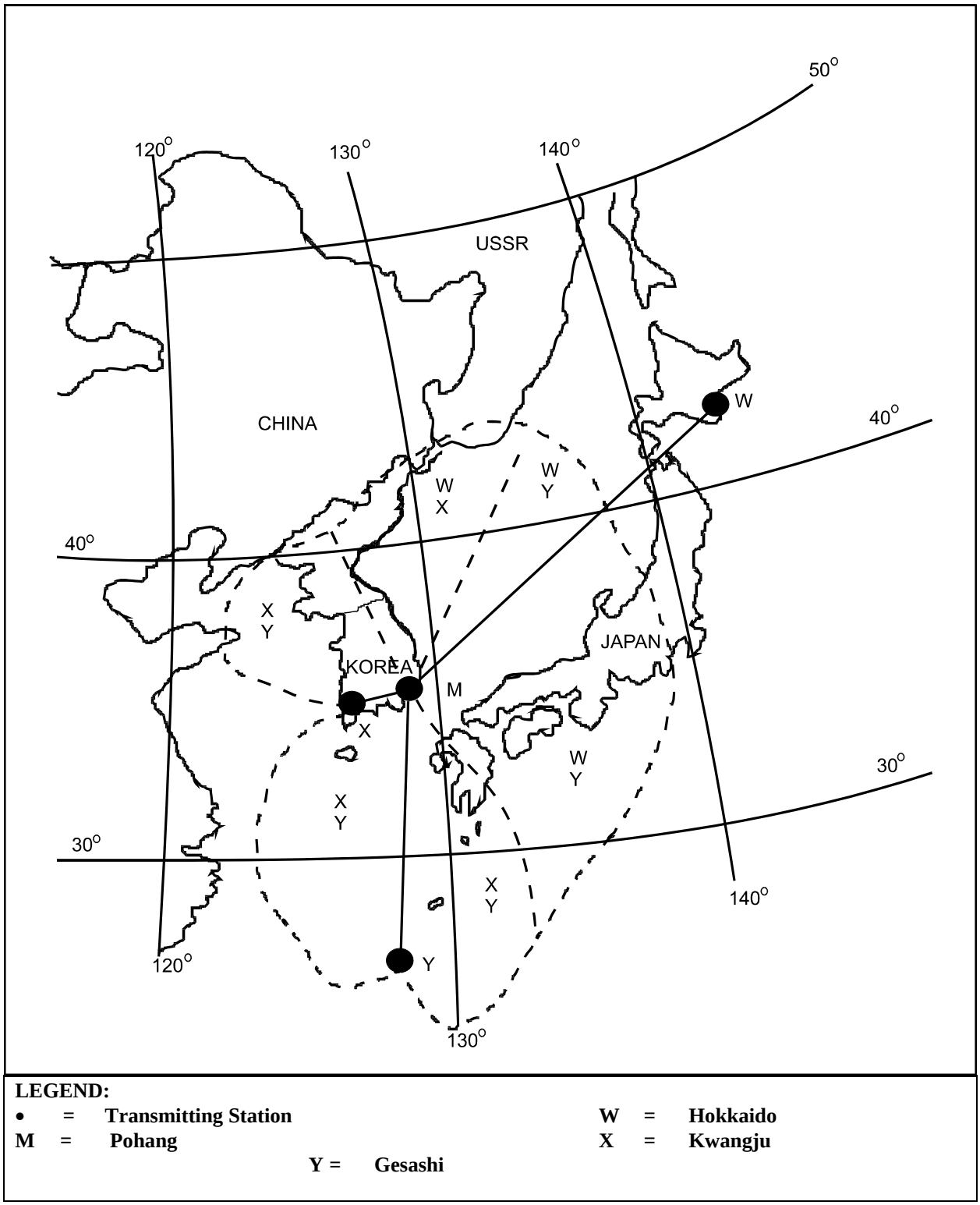
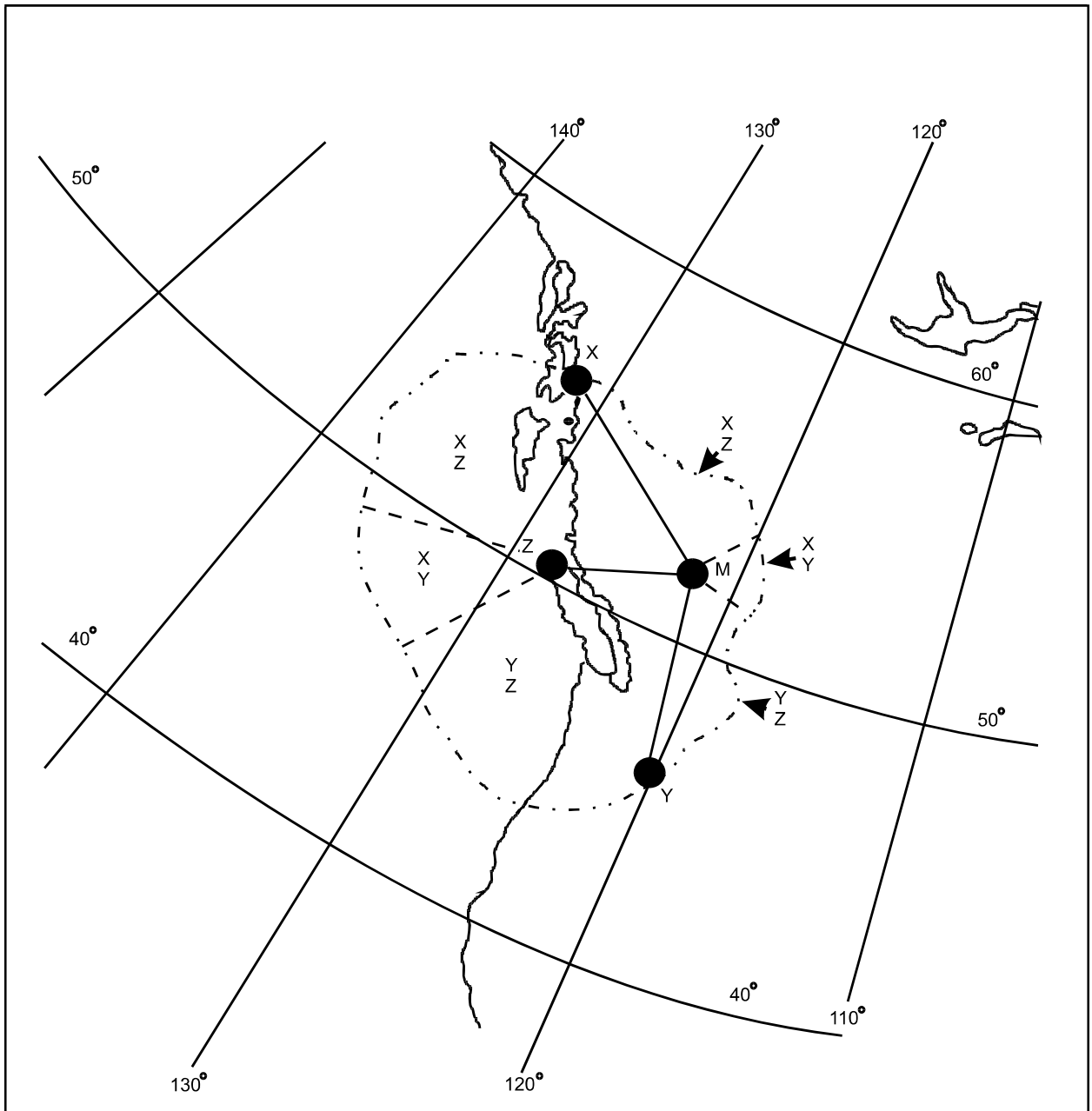


Figure F-2. LORAN-C, Commando Lion Chain, GRI 5970



NOTE: This diagram reflects observed data.	**LEGEND:**	**X = Shoal Cove**
	• = Transmitting Station	**Y = George, Washington**
	M = Williams Lake	**Z = Port Hardy**

Figure F-3. LORAN-C, Canadian West Coast Chain, GRI 5990

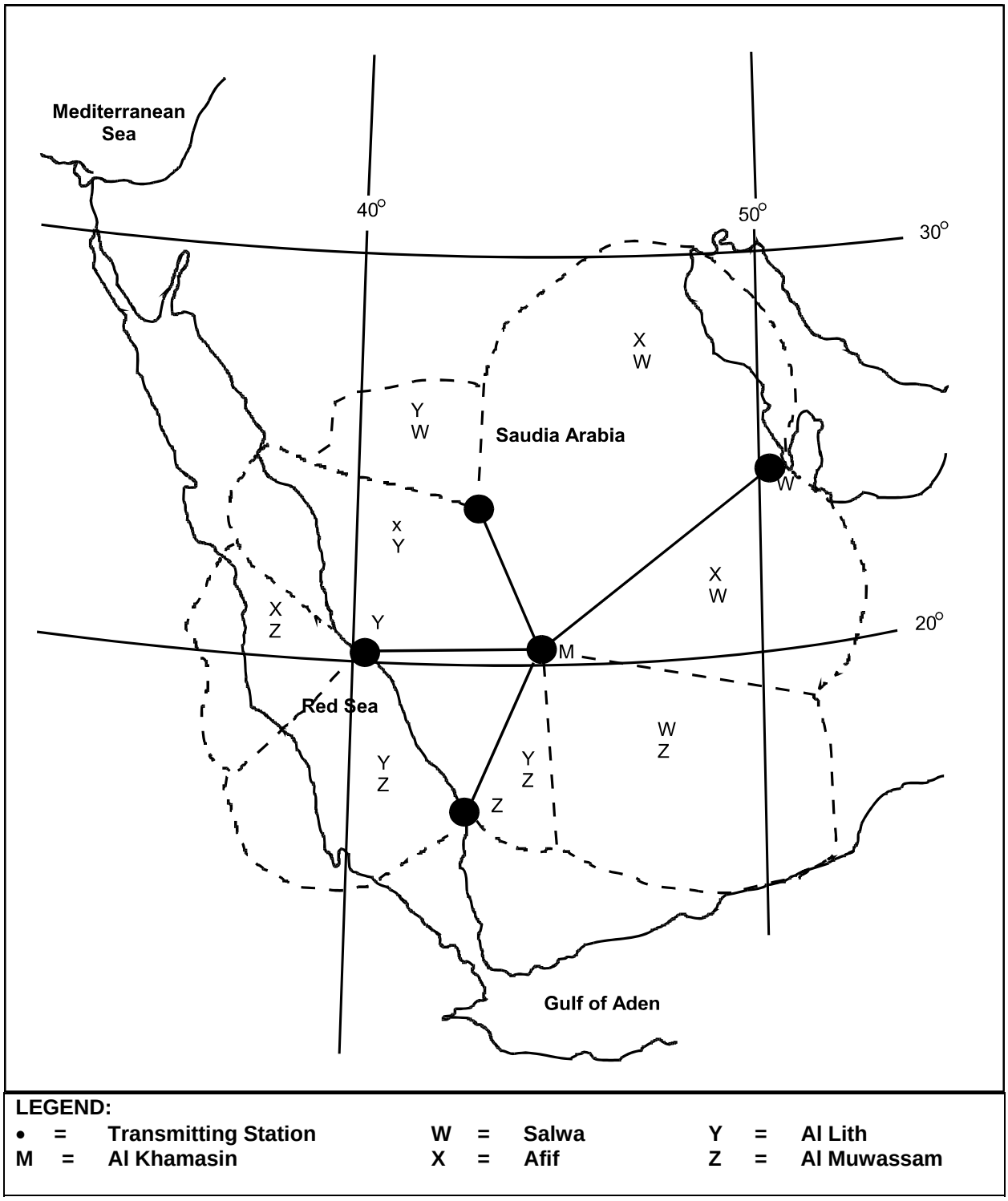
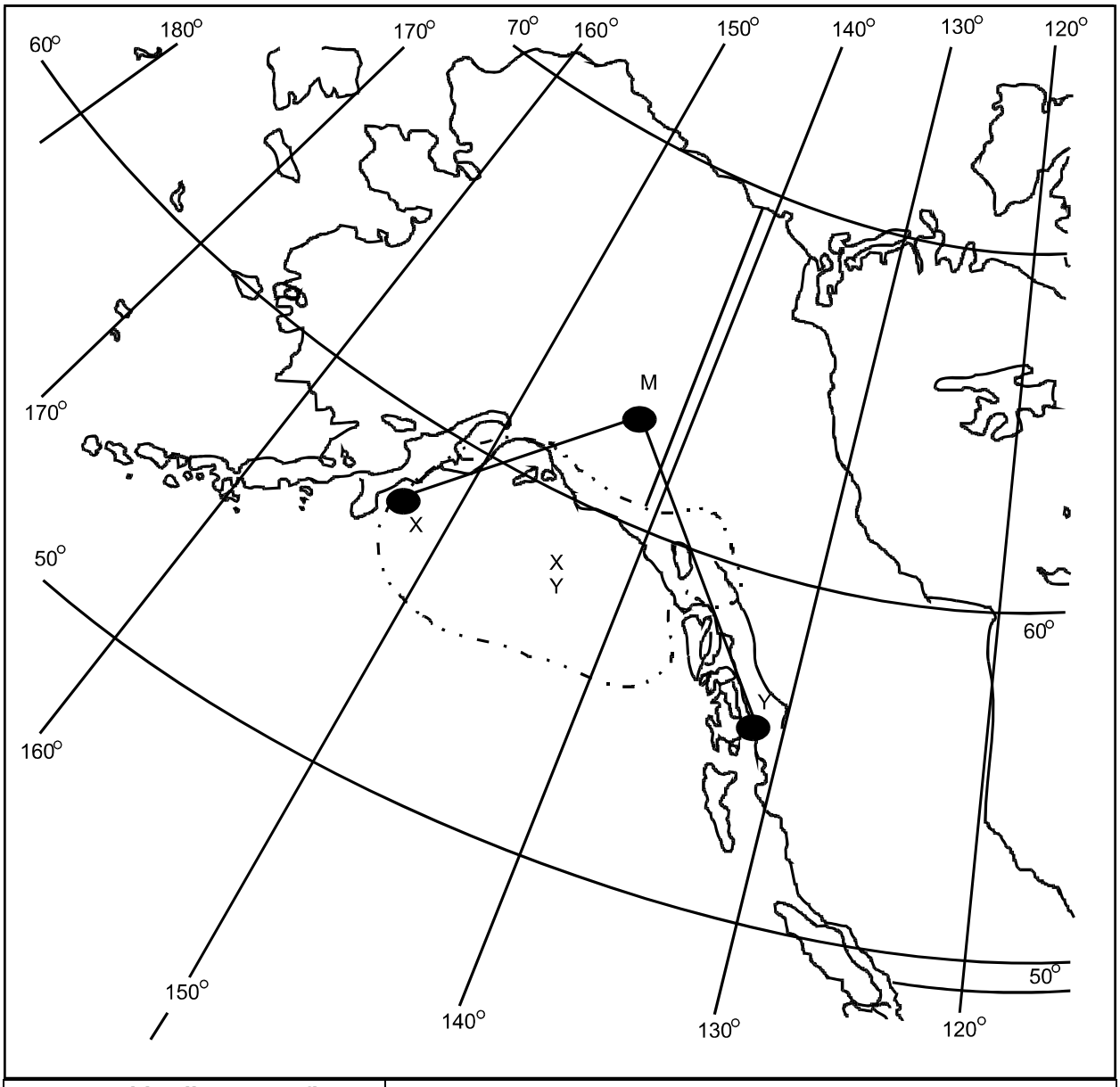
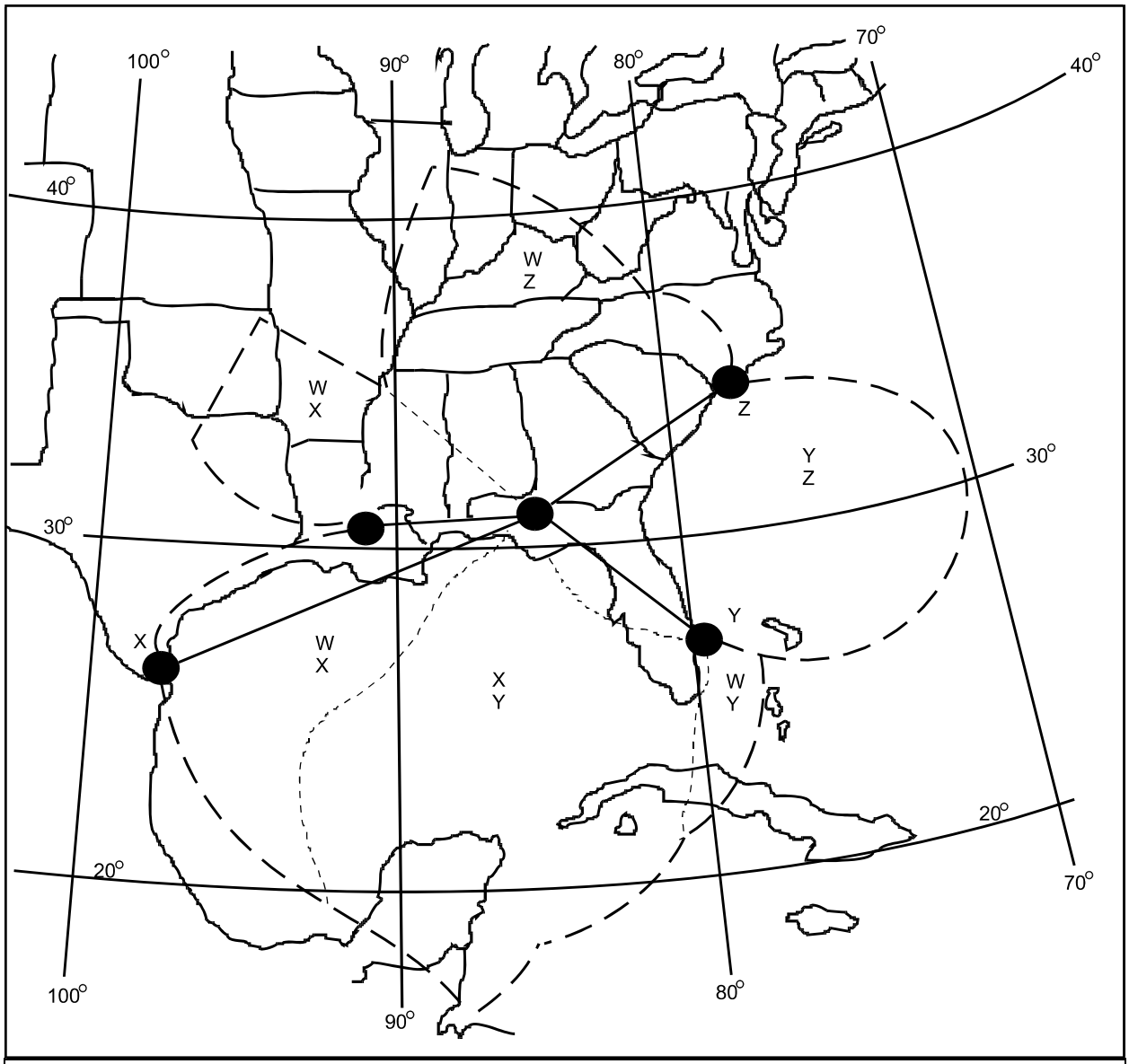


Figure F-4. LORAN-C, South Saudi Arabian Chain, GRI 7170



NOTE: This diagram reflects observed data.	LEGEND:	
	• = Transmitting Station	X = Narrrow Cape
	M = Tok	Y = Shoal Cove

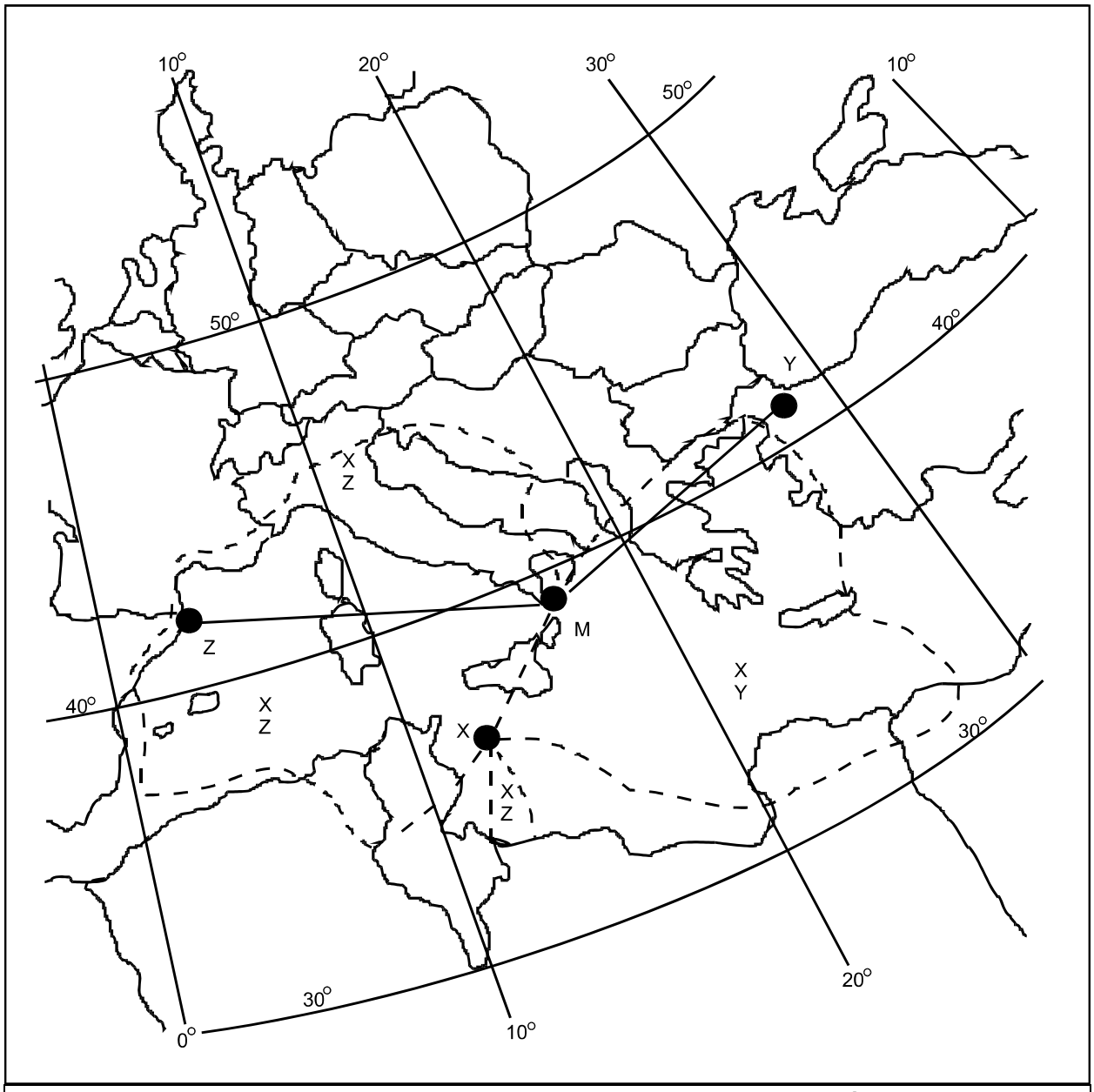
Figure F-5. LORAN-C, Gulf of Alaska Chain, GRI 7960



LEGEND:

•	=	**Transmitting Station**	**W**	=	**Grangeville, Louisiana**
M	=	**Malone, Florida**	**X**	=	**Raymondville, Texas**
Y	=	**Jupiter, Florida**	**Z**	=	**Carolina Beach, North Carolina**

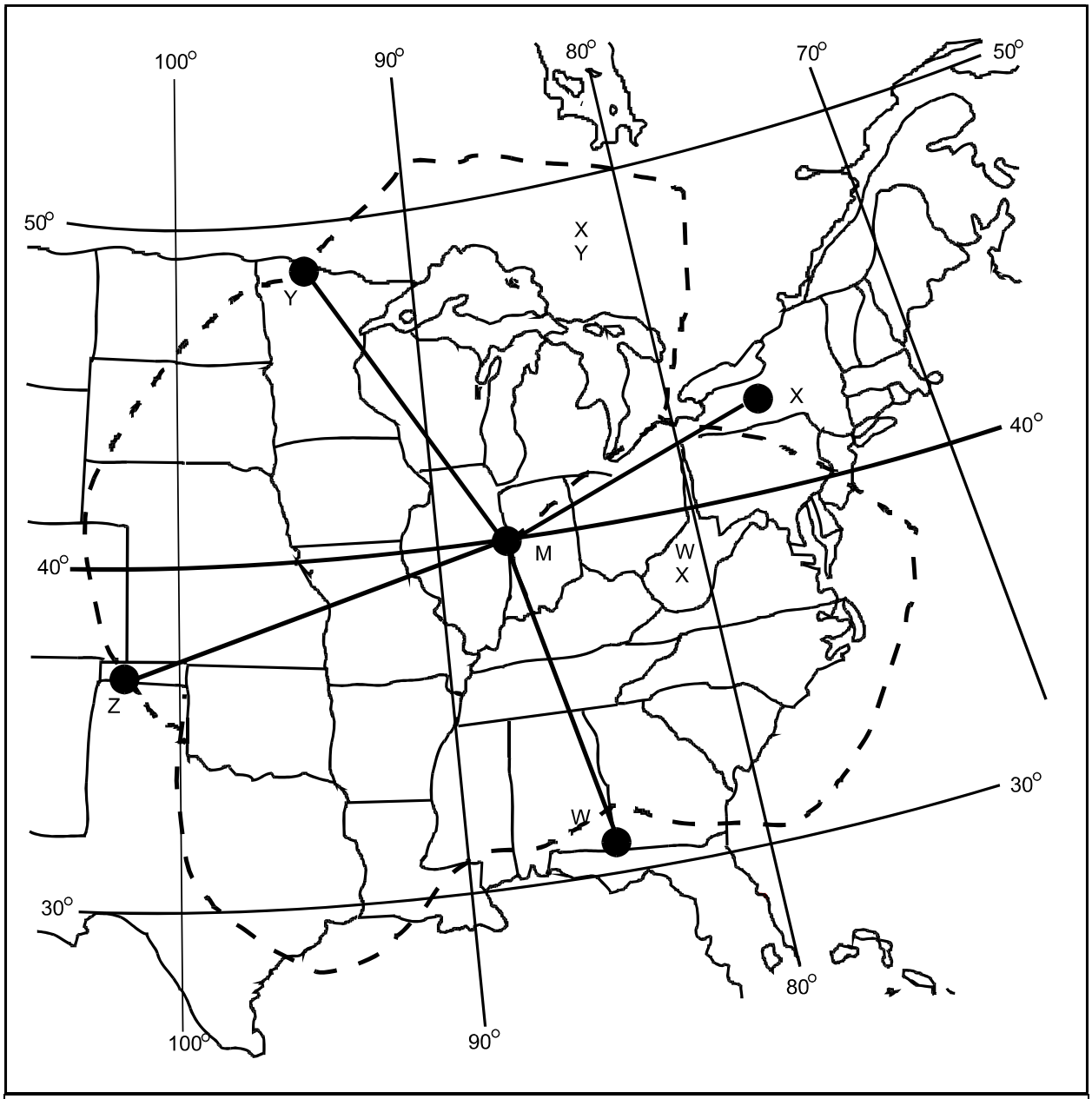
Figure F-6. LORAN-C, Southeast United States Chain, GRI 7980



LEGEND:

•	=	Transmitting Station	X	=	Lampedusa
M	=	Sellia Marina	Y	=	Kargaburin
			Z	=	Estartit

Figure F-7. LORAN-C, Mediterranean Chain, GRI 7990



LEGEND:

•	=	**Transmitting Station**	**W**	=	**Malone, Florida**
M	=	**Dana, Indiana**	**X**	=	**Seneca, New York**
Y	=	**Baudette, Minnesota**	**Z**	=	**Boise City, Oklahoma**

Figure F-8. LORAN-C, Great Lakes Chain, GRI 8970

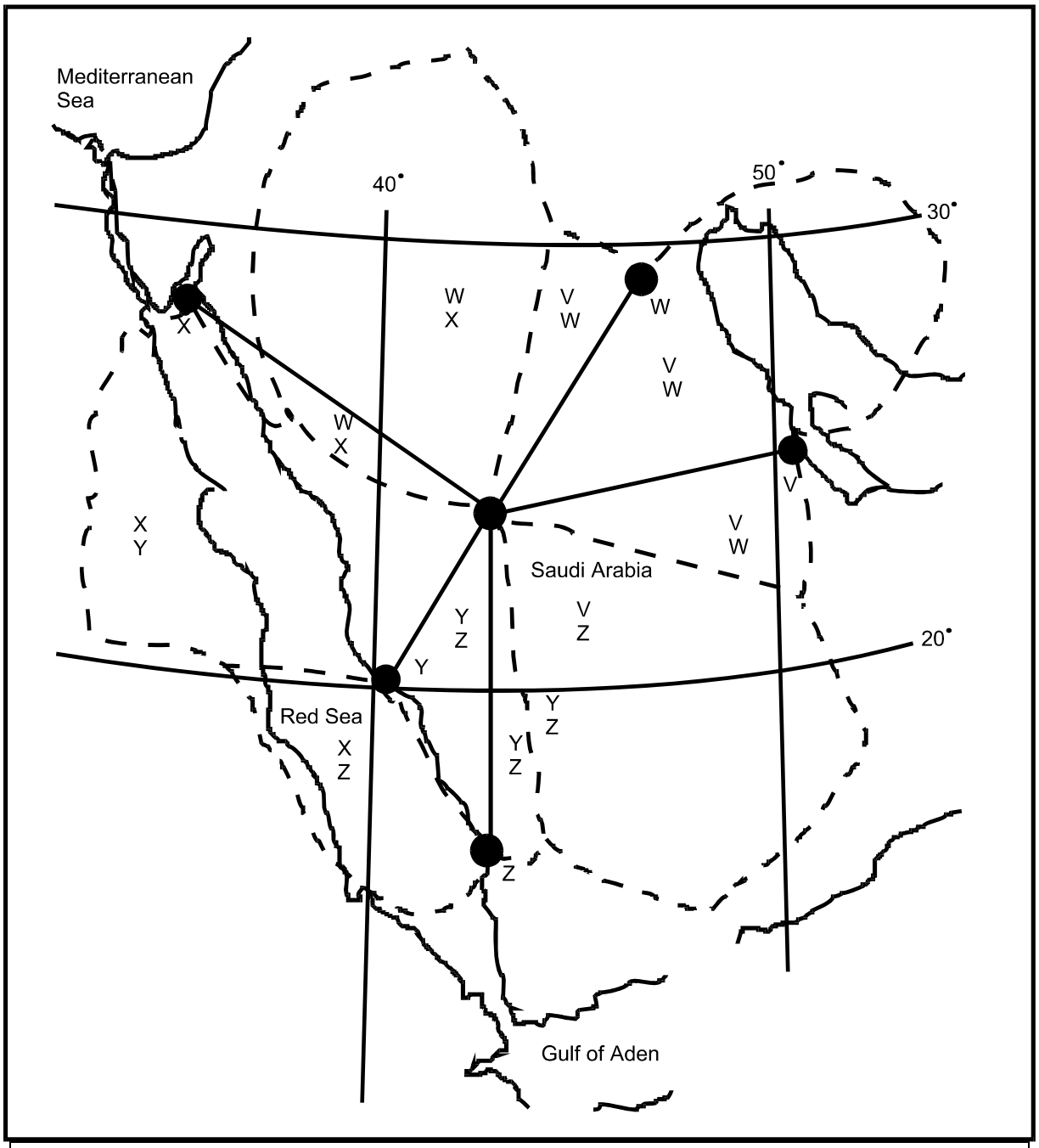
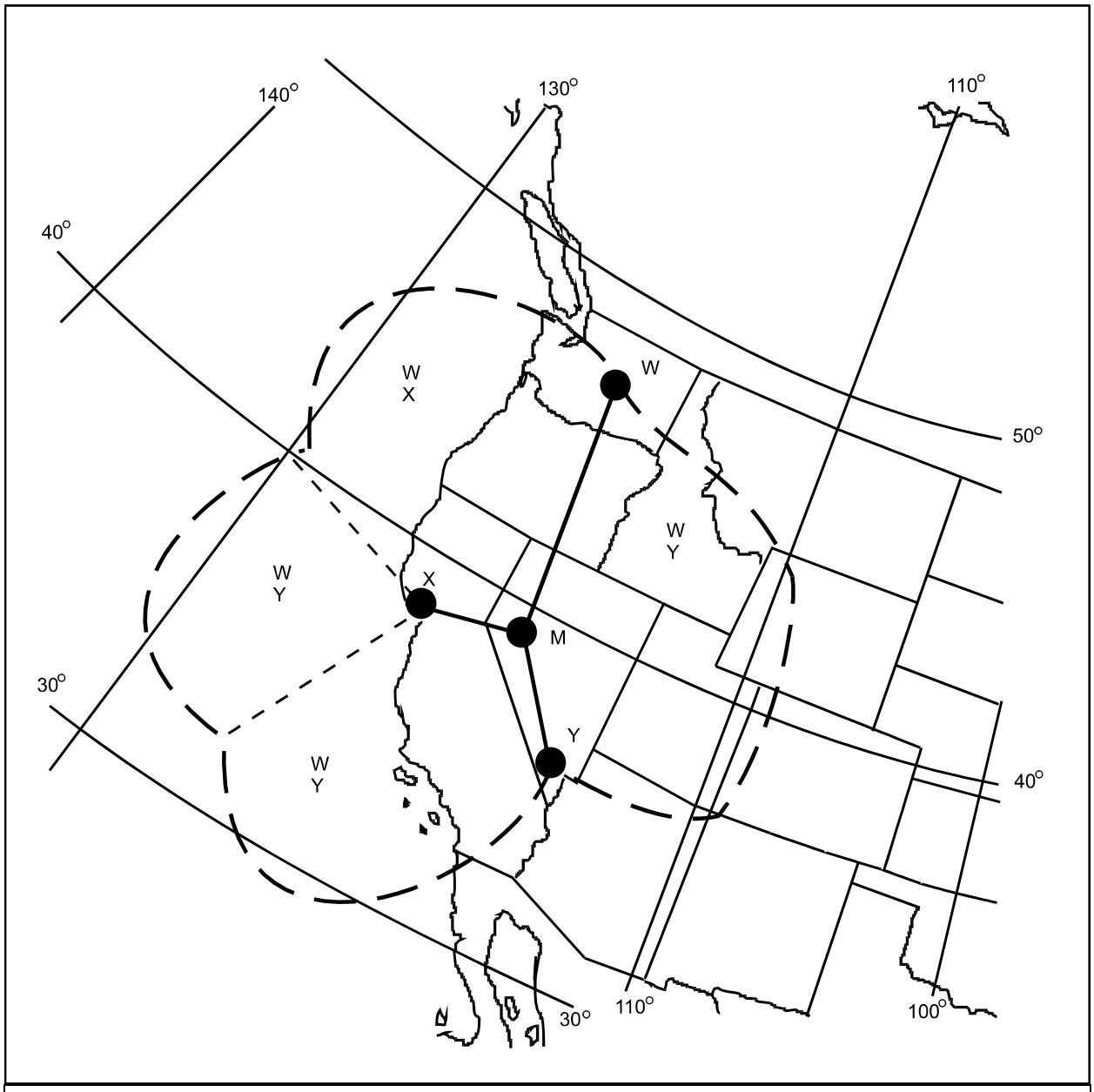


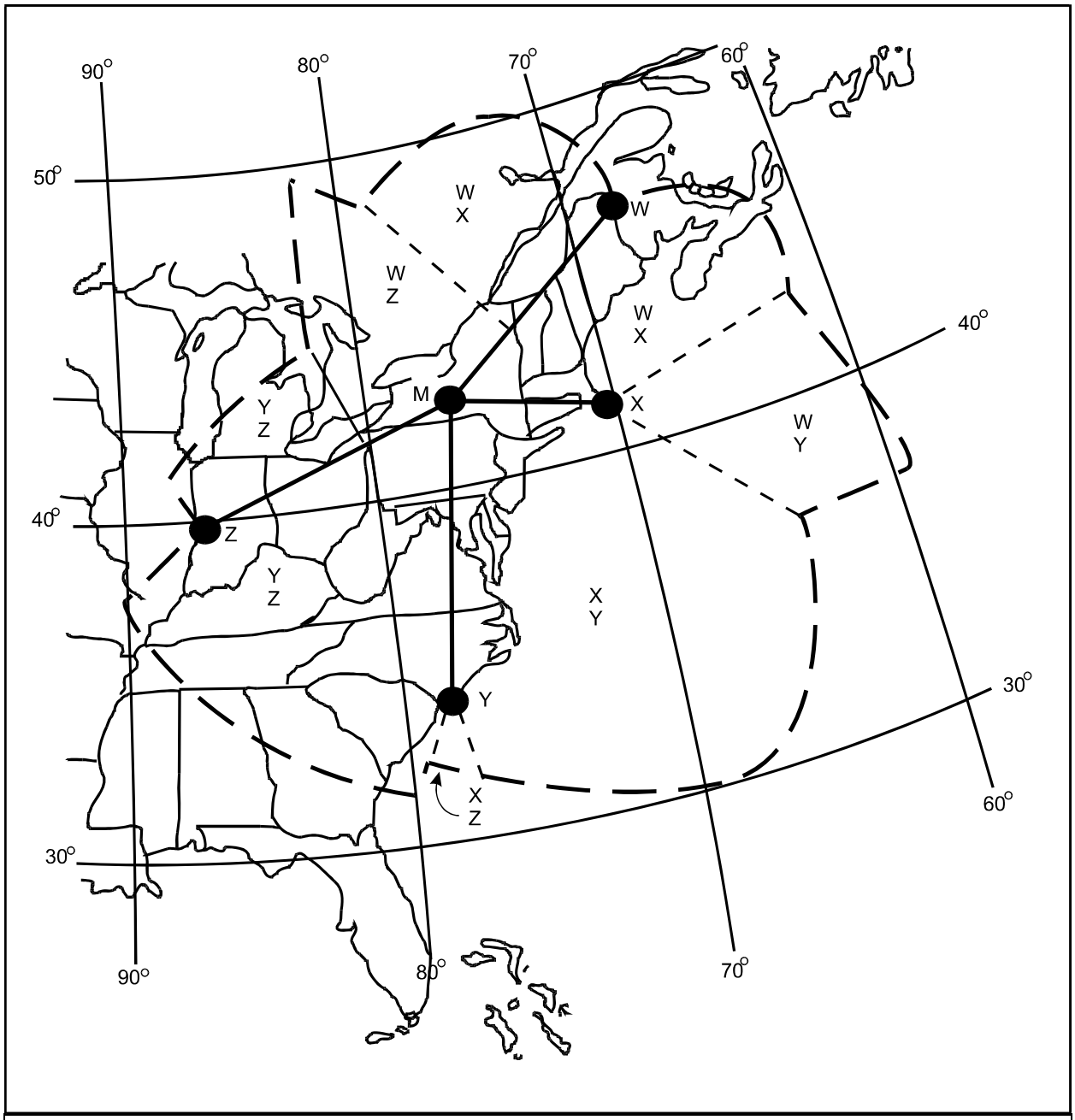
Figure F-9. LORAN-C, North Saudi Arabian Chain, GRI 8990



LEGEND:

•	=	Transmitting Station	W	=	George, Washington
M	=	Fallon, Nevada	X	=	Middletown, California
			Y	=	Searchlight, Nevada

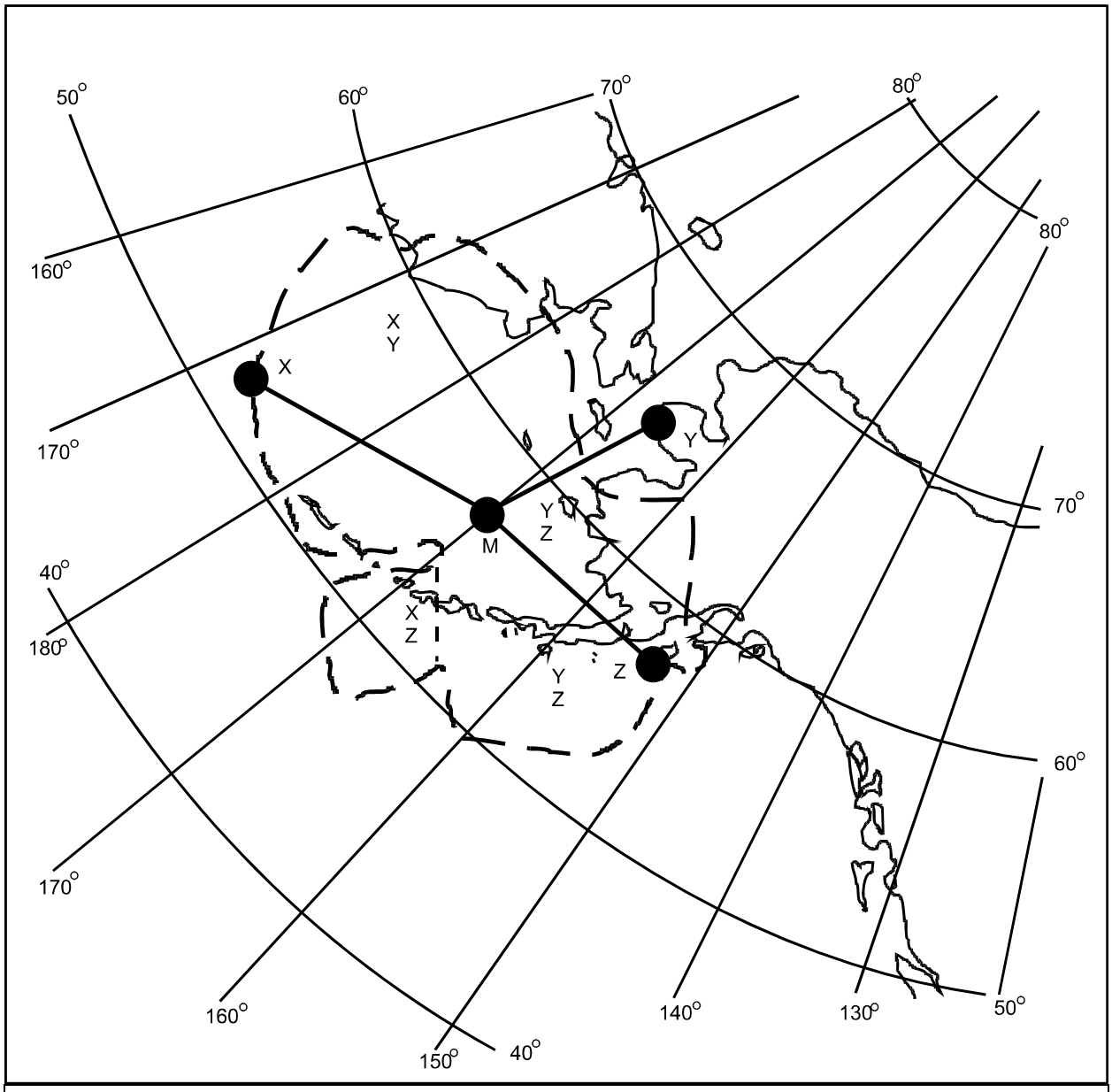
Figure F-10. LORAN-C, United States West Coast Chain, GRI 9940



LEGEND:

•	=	Transmitting Station	X	=	Nantucket, Massachusetts
M	=	Seneca, New York	Y	=	Carolina Beach, North Carolina
W	=	Caribou, Maine	Z	=	Dana, Indiana

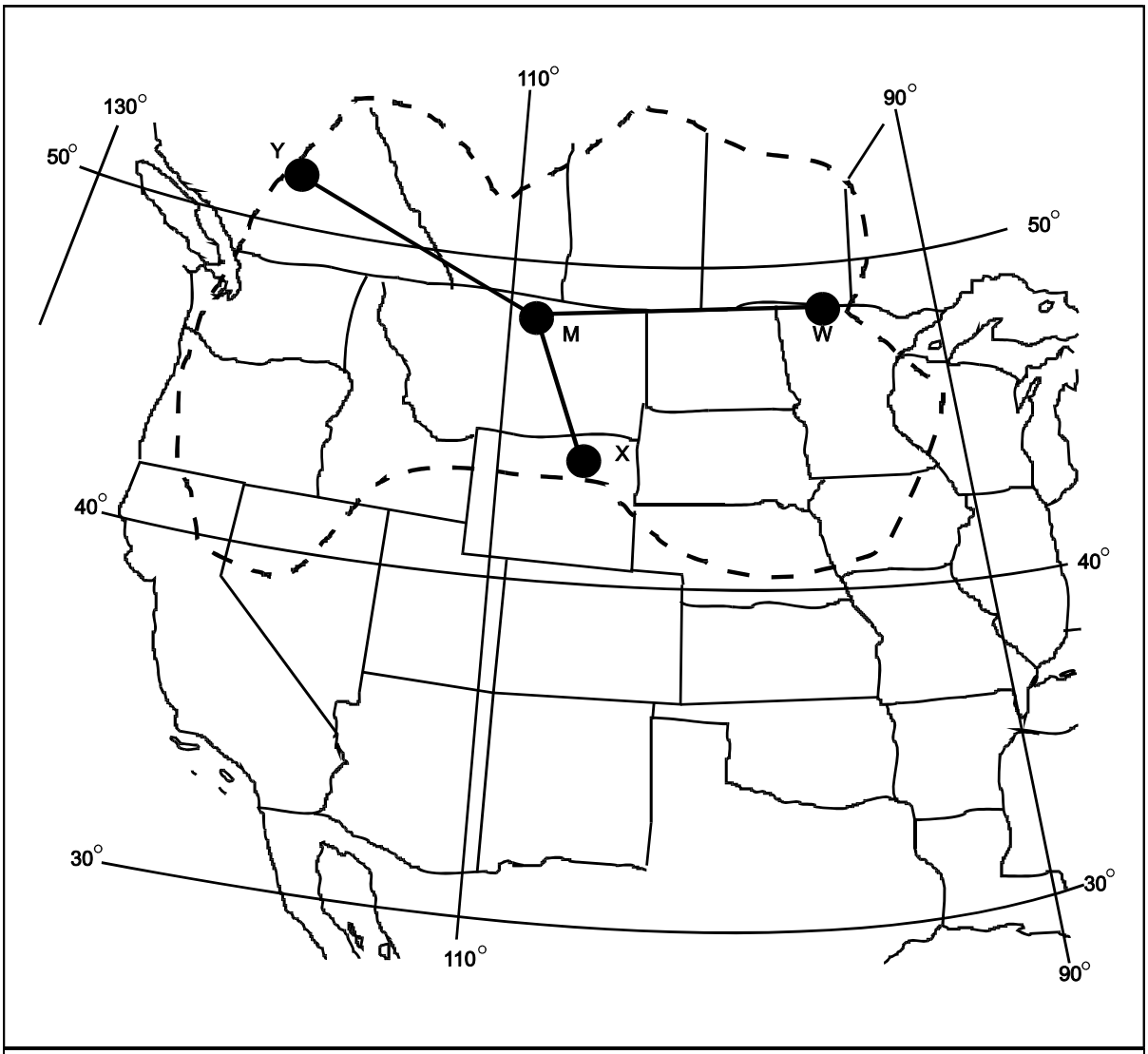
Figure F-11. LORAN-C, Northeast United States Chain, GRI 9960



LEGEND:

• = Transmitting Station X = Attu Z = Narrow Cape
M = St. Paul Island Y = Port Clarence

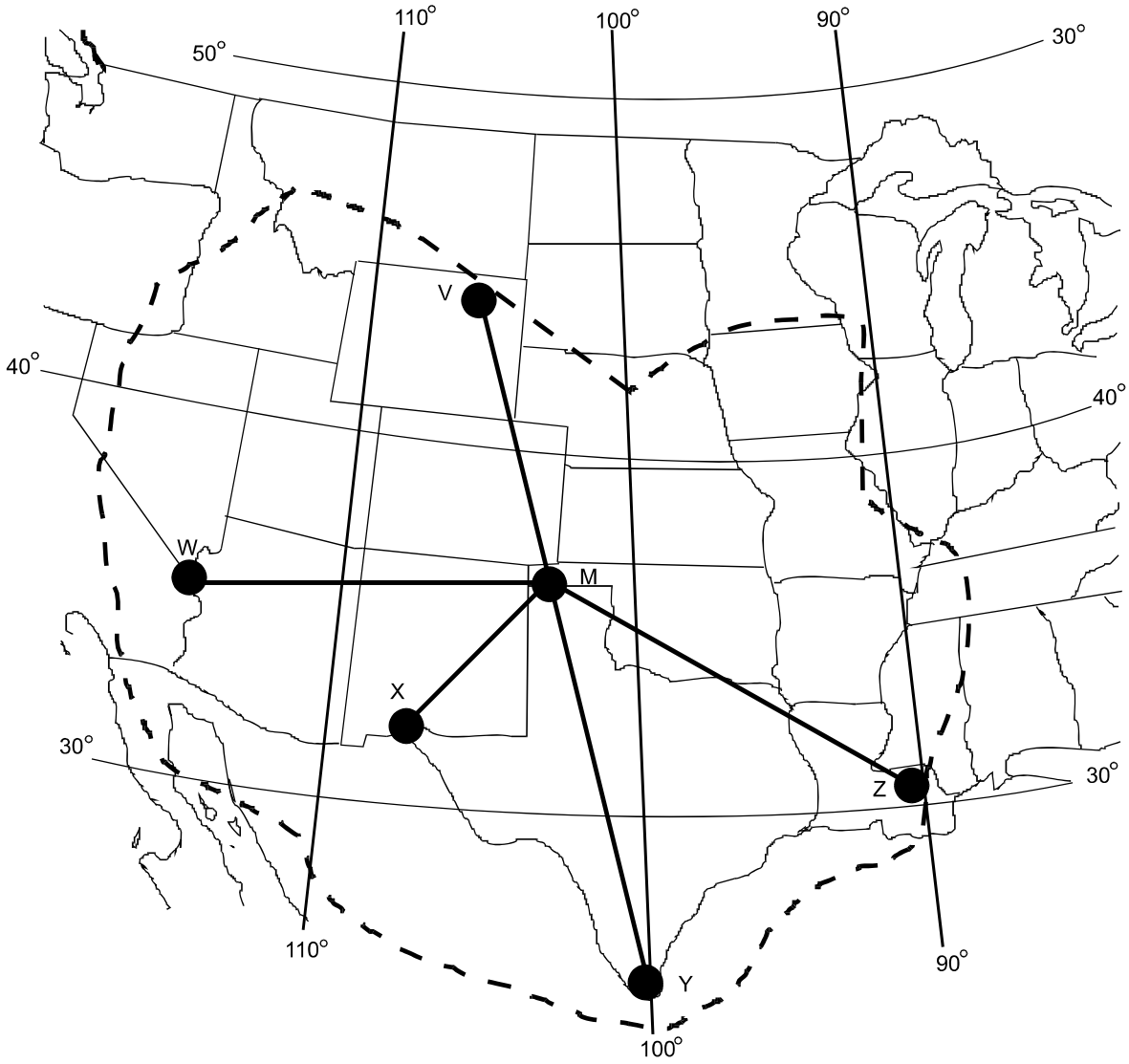
Figure F-12. LORAN-C, North Pacific Chain, GRI 9990



LEGEND:

•	=	Transmitting Station	W	=	Baudette, Minnesota
M	=	Harve, Montana	X	=	Gillette, Wyoming
		Y = Williams Lake, British Columbia			

Figure F-13. LORAN-C, North Central United States Chain, GRI 8290



LEGEND:

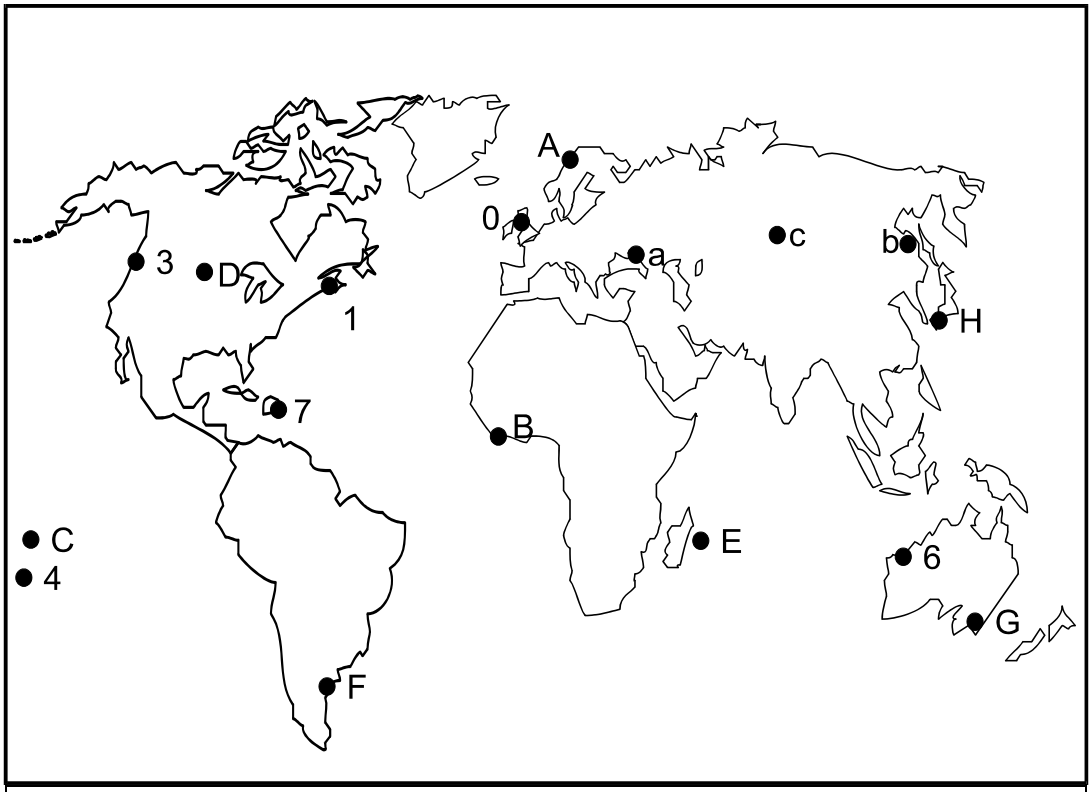
•	=	Transmitting Station	W	=	Searchlight, Nevada
M	=	Boise City, Oklahoma	X	=	Las Cruces,New Mexico
V	=	Gillette, Wyoming	Y	=	Raymondville, Texas
			Z	=	Grangeville, Louisiana

Figure F-14. LORAN-C, South Central United States Chain, GRI 9610

Section II
OMEGA, SIGMA, and VLF Stations

F-2. GENERAL

Figure F-15 depicts the locations of Omega, Sigma, and VLF stations.



LEGEND:	
OMEGA:	
A = Aldra, Norway	E = LaReunion Island, France
B = Monrovia, Liberia	F = Golfo Nuevo, Argentina
C = Haiku, Hawaii	G = Woodside, Australia
D = LaMonde, North Dakota (USA)	H = Tsuchima, Japan
SIGMA:	
a = Krasnobar	
b = Komsomoiskamur	
c = Novosibirsk	
VLF:	
0 = Rugby, England	6 = Banda Sea, Australia
1 = Cutler, Maine (USA)	7 = Puerto Rico, Eastern Caribbean
3 = Jim Creek, Washington (USA)	
4 = Lualaulei, Hawaii (USA)	

Figure F-15. Omega, Sigma, and VLF Stations

Appendix G
Time Zones, Octants, and Regions

To establish a common time and location, met messages are reported in Greenwich mean time while locations are prefaced with an octant of the globe code. Figure G-1 is a world map divided into time zones, global octants, and climatic regions.

G-1. TIME ZONES

Time is calculated from the Greenwich meridian. The middle of the zero time zone passes through Greenwich with its east and west limits 7° 30' on each side. Each 15° zone east and west of the initial zone represents one hour of time. The number of hours that must be added to or subtracted from local standard time to give GMT is indicated for each zone. Political boundaries in the various countries have caused modifications of the time zones. The vertical lines and clear sections are used to show which zones these divisions belong. Where a half hour difference is legal, horizontal lines are used. Where no zone system has yet been adopted, the area is represented by small dots. Where no legal time has been established, the larger dots are used. Variations from zone time are given in hours and minutes. Enter the map with the section location and extract the time correction.

G-2. GLOBAL OCTANTS

Global octants are indicated by bold N-S, E-W lines and octant identifications. Determine the section location on the map and extract the appropriate octant number.

G-3. CLIMATIC REGIONS

The seven climatic regions of the Northern Hemisphere are indicated and identified by the large black numbers 1 through 7.

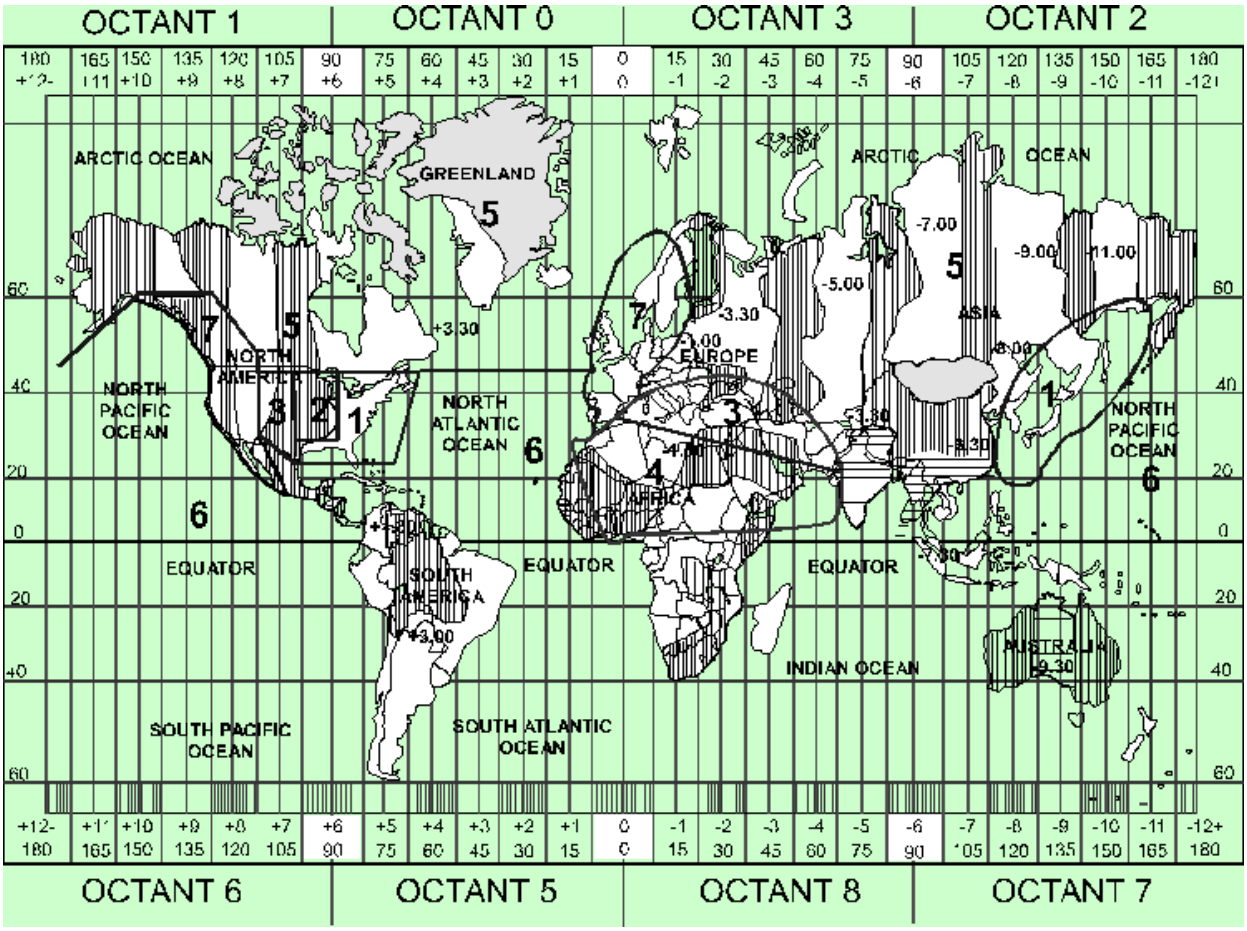


Figure G-1. Time Zones, Octants, and Regions

Appendix H
Safety and Environmental Requirements

Safety is always a primary consideration of soldiers and trainers at all levels. Often, the implementation of safety and environmental procedures becomes counterproductive, preventing units from conducting realistic training. Units must be able to conduct realistic training while meeting all safety and environmental requirements. This appendix addresses these requirements.

H-1. GENERAL

The first rule of safety is: "Do Not Take Chances." Hydrogen gas as well as methanol are extremely flammable. Special care in handling, storing, and disposing of waste is required to prevent injury or environmental hazards.

H-2. HYDROGEN

Mixtures of hydrogen and air can be highly explosive. Personnel using commercial hydrogen or generating it must remove all possible sources of flames and sparks. Hydrogen burns with an almost invisible flame that is difficult to extinguish. If hydrogen ignites, use powder fire extinguishers only.

a. **Storage**. Warning signs must be posted in all areas where hydrogen is stored. The hydrogen cylinders and the hydrogen generators should not be exposed to extreme heat or the direct rays of the sun. The area should be well ventilated and at least 50 feet away from ignition sources. Material Safety Data Sheets (MSDS) must be kept on file at each location.

b. **Handling**. All sources of static electricity must be provided a path to ground. All personnel and equipment must be grounded when using or generating hydrogen. Fire extinguishers must be readily available. Personnel must adhere to the detailed safety requirements outlined in Chapter 8.

c. **Disposal**. Commercial hydrogen produces no harmful waste. When using the hydrogen generator set, AN/TMQ-3, a cloudy substance, calcium hydroxide, is released into the water during the process. This by-product is an environmental hazard. Before disposing of this deposit and the calcium hydride containers, met personnel must check with local agencies and comply with their procedures.

H-3. METHANOL/METHANOL CHARGE MIXTURE

Methanol is listed as a hazardous material because of its flammability. Vapors are slightly heavier than air and tend to settle to the ground. It is also considered a toxin especially with regard to prolonged exposure.

a. **Storage**. The storage area must be well ventilated and at least 50 feet away from sources of spark and flame. The area must be designed so as to contain all spills. The methanol/methanol water charge should be covered so as not to expose the containers to direct sunlight. No smoking signs must be displayed on all sides of the area. MSDSs must be kept on file at each location.

b. **Handling**. All sources of static electricity must be provided a path to ground. Personnel working with methanol/methanol water charge mixture and equipment must be grounded. Personnel shall wear all the protective clothing. Fire fighting equipment must be readily available and all personnel entering the area must know where it is located. Loading the chemicals onto the storage trailer requires three people or mechanical assistance. Flammable placards shall be affixed to the trailer. Standard work clothes are acceptable for loading, providing personnel protective clothing is immediately available in case of a leak or spill. The use of a spill control pallet is recommended when transferring the chemicals to contain spills. A ground cable is required connecting the methanol pails and the hydrogen generator as well as the transfer pump and the hydrogen

generator. Should either of the chemicals be splashed in the eyes or on any of the personnel, immediately flush with water. If methanol is ingested get immediate medical attention. Detailed safety requirements for inflation are outlined in Chapter 8.

c. **Disposal**. The hydrogen generator, AN/TMQ-42, produces approximately 0.25 gallons per hour of a 15-20 percent solution of methanol in water as a waste discharge. This is still a flammable liquid having a flash point of 103°F. It should be collected in an empty 5-gallon methanol container with the original label altered to indicate "waste methanol." This and the other empty containers should be returned for recycling or disposal through the local environmental quality office or to the appropriate civil authority.

Appendix I

Environmental Awareness

Commanders, unit leaders, and soldiers have specific duties and responsibilities concerning protection of the environment. Soldiers are expected to do what is right in the absence of specific guidance. Unit leaders and commanders must be competent and confident in the area of environmental stewardship. Not all leaders are required to be environmental experts; however, they must be aware and responsive to compliance and prevention issues required during the execution of their duties. The information contained herein is considered an overview of expected duties and responsibilities in order to build a foundation of basic environmental awareness. Throughout is reference to material for further reading; research of these documents provides a complete explanation of legal and ethical responsibilities.

Note: Equivalent U.S. Marine Corps guidance documents include MCO P1200.7S and MCO P5090.2A.

SECTION I – ARMY ENVIRONMENTAL AWARENESS

GENERAL POLICY STATEMENTS

I-1. The Army's environmental vision states: "The Army will be a national leader in environmental and natural resource stewardship for present and future generations as an integral part of our mission". To achieve this vision, the Army's environmental strategy places a high priority on sustained compliance with all environmental laws; takes into account the restoration of previously contaminated sites; focuses on pollution prevention; and accounts for the conservation and preservation of natural resources.

I-2. The Army environmental ethic calls for the chain of command to establish and support a stewardship climate which supports *compliance*, obeying the law; *prevention*, the concept of reduce, reuse, recycle; *conservation*, control and protection of natural resources; and *restoration*, the cleanup of contaminated areas. This ethic supports caring for the environment while conducting realistic training.

I-3. All Army personnel should become familiar with these policy statements; they are established so that our natural environment will be available for present and future generations. Complete information regarding these polices can be obtained in Section II of *The Field Artillery Guide to Environmental Considerations*.

SECTION II – METEOROLOGY ENVIRONMENTAL CONSIDERATIONS

FIELD ACTIVITIES

I-4. The meteorological (Met) section provides accurate and timely meteorological data to both artillery and other tactical units. This data is gathered via highly mobile, automated data processing and met data acquisition systems. In order to obtain this data, various processes are used to launch and track a balloon-borne radiosonde. These processes apply and produce substances that have the potential to cause serious damage to the environment. This section will identify and address the various preventive measures that can be utilized in order to decrease possible environmental damage while conducting realistic training from the met section, associated vehicles, and personnel involved in training and operations.

I-5. Key field environmental considerations include, but are not limited to, the following:

- Vehicles should stay on established roads, trails, firing points, and firebreaks, unless conducting specific cross-country maneuver exercises.
- Follow land contours rather than driving up and down hills or along creeks.
- In order to minimize siltation of streams; use bridges or low water crossings when crossing permanent streams. If crossing through a stream becomes necessary, then do so by the most direct route (90-degree angle).
- Establish refueling and maintenance areas away from wetlands, drainage areas, and near or over water sources.
- Federal law prohibits the removal of artifacts from federal property. Do not excavate, remove, damage, or otherwise alter or deface any archaeological resource located on a military reservation.
- Avoid off-limit areas for known archaeological sites during military training exercises. Penalties can be up to $250,000 for knowingly disturbing a site.
- Be aware of and avoid nesting, bedding, and habitats of all species of birds and animals.
- Use radar-scattering camouflage netting as outlined in the field manual; not live vegetation.
- When planning training activities, conform to installation and community noise-abatement regulations. Identify, mark, and abide by off-limit boundaries.
- Open fires, such as burning of garbage, refuse, and rubbish is not allowed on range areas.
- Conform to field sanitation and medical standards when using soakage pits for wash water, liquid kitchen wastes, and grease traps per FM 21-10, *Field Hygiene and Sanitation.*
- Establish field satellite-accumulation site and procedures.
- Police field locations and establish field trash-collection point and procedures. Remove materials packed into training area on departure from the training area.
- When the training exercise is complete, repair any field damage such as ruts from vehicles and other emplacements.
- Conduct all training with a concern for conservation and future use of range training areas.

HAZARDOUS MATERIAL AND HAZARDOUS WASTE

I-6. The Resource Conservation Recovery Act (RCRA) of 1976 is the framework for managing hazardous waste and has established standards for identifying, classifying, and storing of these wastes. RCRA regulations require those involved in managing hazardous substances to be properly trained, and the training to be properly documented.

I-7. Key hazardous material and hazardous waste environmental considerations include, but are not limited to, the following items:

- Personnel dealing with hazardous materials should be trained in proper handling, containment, cleanup, and reporting procedures.
- A Material Safety Data Sheet (MSDS) must be on file, and made available to all personnel regarding hazardous material.
- Calcium hydroxide, a by-product formed from using the hydrogen generator set, is an environmental hazard. Conform to installation policy when storing, handling, and disposing of this waste.
- Methanol and methanol in water is used with the hydrogen generator; both are hazardous materials due to flammability and toxicity. Conform to installation policy when storing, handling, and disposing of this waste.
- Battery electrolyte (acid) from damaged batteries should be drained and disposed of through turn-in via installation policy and maintenance SOP. Refer to TB 43-0134, *Battery Disposition and Disposal,* for complete procedures regarding battery handling and disposal.
- Never allow the accumulation of more than 55 gallons of a hazardous waste, or 1 quart of acutely hazardous waste, at the satellite accumulation point. Process all hazardous waste in a timely manner.
- Hazardous waste containers should be kept closed when not in use, kept free of rust and leaks, and stored separately from incompatible wastes.
- Incompatible wastes must never be transported on the same vehicle.
- Ensure that all DOT and hazardous waste transportation requirements are met prior to transporting hazardous material or hazardous waste on public highways.
- Check with local Environmental Office for transportation procedures within the installation boundary.
- For complete information regarding storing and handling of hazardous materials refer to TM 38-410, *Storage and Handling of Hazardous Materials.*

MATERIAL SAFETY DATA SHEET

I-8. A Material Safety Data Sheet (MSDS) is a summary of information on a given chemical identifying material, health and physical hazards, exposure limits, and precautions. A MSDS describes the hazards of a material and provides information on how the material can be safely handled, used, and stored. Insist on receiving a copy of a MSDS when receiving a hazardous chemical from supply, and retain it for when or if you turn in the material. Periodically review each MSDS pertaining to your unit. This will assure a quick response when identifying symptoms and handling emergencies.

I-9. Unfortunately, there is no specified format for a MSDS, and it doesn't contain all known data of a chemical, but there are typical components. These are outlined in 29 CFR 1910.1200. Use the following information as a guide toward what to expect on most MSDS forms.

Section/Topic	Contents
Section 1 - General Information	Manufacturers' name and address Trade or common name of product
Section 2 - Hazardous Components	NIOSH and/or CAS Number Chemical name and percentage
Section 3 - Physical Properties	Boiling point, freezing point, water solubility, etc. Appearance and odor under normal conditions
Section 4 - Fire & Explosion Hazard	Fire-fighting equipment Any unusual fire and explosion hazards
Section 5 - Health Hazard	Routes of entry into the body Emergency and first aid procedures
Section 6 - Reactivity Data	Conditions to avoid Incompatibility with other materials
Section 8 - Control Measures	Recommended respiratory and ventilation Personal protective equipment, if needed
Section 9 - Special Precautions	Handling and storing precautions
Section 10 - Transportation	Applicable regulations Hazards class and required labeling

Figure I-1. Material Safety Data Sheet

MAINTENANCE

I-10. The met station leader assigns a hazardous material/hazardous waste (HM/HW) spill coordinator. This person ensures the accountability, proper storage, and disposal of all HM/HW, and ensures that HM/HW spills are immediately contained and reported.

I-11. Key maintenance environmental considerations include, but are not limited to, the following:

- Refueling operation SOPs should address practices to minimize spills.
- Implement preventive maintenance on all heavy equipment to ensure petroleum products will not be released from the belly pan.
- Ensure pollutants are not discharged into storm or washrack drains or poured on the ground or along fence lines. Some common pollutants are oil, solvents, soap, diesel, gasoline, battery acid, chemicals, waste antifreeze, paint, and grease.
- Parts containing asbestos, such as brake shoes, clutch plates, and equipment insulation should be removed, collected, and disposed according to installation policy.
- The least hazardous or preferably, non-hazardous material to perform a function should be used, unless previous research of options clearly indicates otherwise. The Defense Logistics Agency (DLA) produces a manual, *Environmental Products*, to assist in this process.
- Do not mix fuel, oil, or antifreeze together. This is considered a mixed waste.

SUPPLY

I-12. The met section is required to have a complete inventory of HM/HW generated by the section. The met station leader must know what chemicals the unit requires, where and how they are stored, how much hazardous waste is generated, and necessary spill response procedures. He/she should coordinate with the unit S3 or ECO to ensure this information is incorporated into the unit SOP.

I-13. Key supply environmental considerations include, but are not limited to, the following items:

- Requisition only supplies needed and authorized, avoid excessive stockpiling of materials.
- Maintain an accurate inventory in SOP of hazardous waste used by the met section. This listing should include waste by volume, type, generating process, and location.
- Use of used oil tanks for disposal of solvents, antifreeze, or other HM/HW is against regulation. Storage of hazardous material must be in clearly marked DOT-approved containers.
- Actively support a unit-recycling program.
- Ensure tires and batteries are properly turned in for recycling.
- Ensure used batteries are turned in on a one-for-one basis.

SPILL RESPONSE

I-14. Generally, only persons specifically trained to respond to a spill should handle unit spills. However, all personnel should, at a minimum, report the spill, and be aware of the following four basic steps to spill response:

- Protect yourself. Use personal protective equipment (PPE) specified in the MSDS.
- Stop the flow. This may be as simple as placing the container upright or closing a valve.
- Contain the spill. Place absorbent material around the spill, and protect drains and ditches.
- Report the spill. Notify supervisor, and other key personnel.

I-15. Each unit is responsible for the cleanup of their own spills, as long as no personnel are put in danger. After the above four steps are completed, take the necessary steps to cleanup the spill. Information on cleanup procedures can be found on the MSDS, unit SOP, or contact installation environmental staff for guidance. Turn in the spilled material and absorbent to the Defense Reutilization Marketing Office (DRMO), or another designated point if a DRMO is not available. Also, ensure there are adequate spill supplies on-hand for future use.

I-16. Key spill prevention, response, and cleanup considerations include, but are not limited to, the following items:

- A spill prevention and response section should be included in the unit SOP outlining installation spill plan requirements.
- Make maintain a spill cleanup kit near any satellite-accumulation area, or where a potential for spill exists. The kit should contain, at a

minimum, absorbent material, shovel, brooms, gloves, and appropriate containers. Units who have a potential for release or spill that may impact streams should also maintain booms for containment.

- Drip pans should be used under vehicles and equipment where spills are likely to occur.
- Spills of oil, fuel, or other hazardous pollutants over 5 gallons in volume, 100 square feet in area, or in any waterway should be reported immediately to the chain of command.
- All topsoil contaminated with oil should be removed, properly disposed, and replaced by the unit. While awaiting disposal, keep the excavated soil covered to prevent runoff in case of rain.

SECTION III – REGULATORY REQUIREMENTS

LAWS AND REGULATIONS

I-17. Military facilities are subject to federal, state, local, and host nation environmental laws. When the requirements differ, the most stringent applies. Ignorance of environmental laws is not an excuse for non-compliance, and it will not protect commanders, soldiers, or the military services from civil and criminal liability. Figure I-2 lists the federal and military laws and regulations that are frequently encountered by Army personnel; however, it is not inclusive of all requirements.

I-18. Additionally, environmental law varies with differing countries, states, and cities. What is legal in one area may be illegal in another. Each installation Environmental Office knows the laws for that locality, and should be consulted on environmental considerations during the planning and execution of training.

I-19. Army units outside the United States (OCONUS) that are not subject to federal environmental regulations decreed by the Environmental Protection Agency (EPA) should comply with the Final Governing Standards (FGS) of the host nation (HN). In areas where a HN has minimal or no environmental laws and regulations, comply with the *Overseas Environmental Baseline Guidance Document (OEBGD)* provided by the Department of Defense, AR 200-1, *Environmental Protection and Enhancement*, and AR 200-2, *Environmental Effects of Army Actions*.

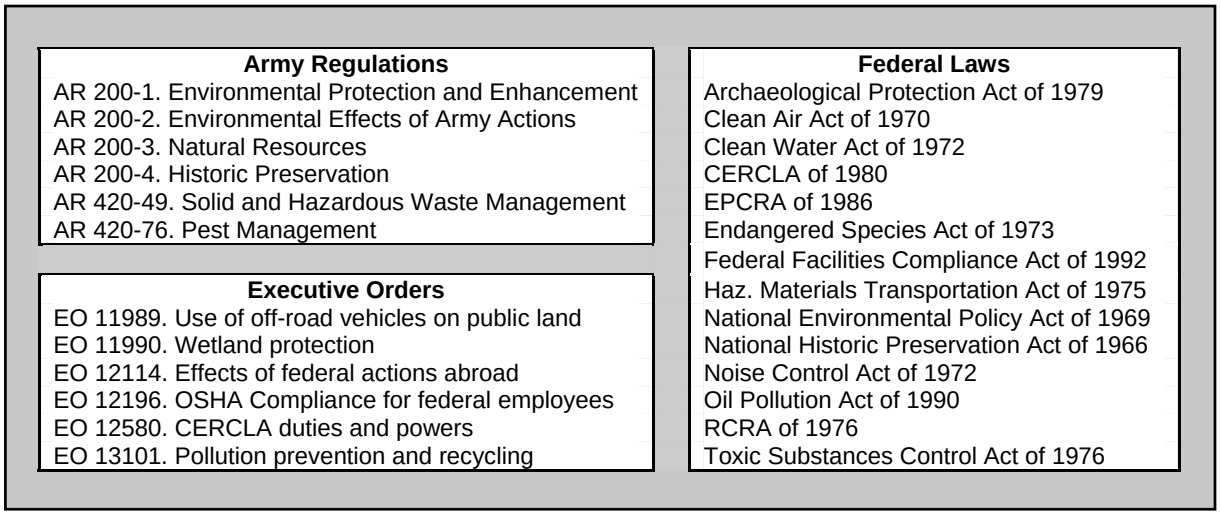


Figure I-2. Environmental Laws and Regulations

REGULATORY TRAINING REQUIREMENTS

I-20. Regulatory agencies exist which require environmental training. This training may be at the awareness level for all personnel or at a more specialized level designed for specific personnel. The installation Environmental and Safety Offices can best assist in determining your training requirements and who to contact for additional information. Table I-1 is provided as a reference of possible training requirements for the met section personnel.

Table I-1. Regulatory Training Requirements

NOTE: The depth or level of training will vary between target audiences. For example, K and E will need in-depth training, while A will only require broad overviews. The letters K, E, N, or A denotes target audience, and are listed below:

Knowledge	Personnel who administer, implement, or comply with contents of regulations such as program manager and technicians in the environmental field. Also includes organizations that need in-depth knowledge of the environmental laws/regulations/programs, such as Staff Judge Advocate.
Executors	All personnel who supervise or actually handle responsibilities dealing with environmental programs, to include ECOs, technicians, and workers. Also includes unit personnel required to execute responsibilities with environmental ramifications as part of their mission.
Need to Know	Personnel who may encounter environmental issues as part of their mission. This may include personnel within the following activities: Engineers; Designers; Emergency Personnel; Safety; Reserve Components; First-line Supervisors; Crew Chiefs; NCO's; and various unit personnel as identified by the installation Environmental Office and their supervisors
Awareness	Public Affairs Office, Reserve Components, other unit personnel.

Training Topic	Regulatory Reference	K	E	N	A
Hazardous Materials/Waste Compliance Training	29 CFR 1200; 40 CFR 262.34, 264.16, 265.16; 49 CFR 172	*	*	*	*
Hazardous Waste Operations (HAZWOPER) for IR	29 CFR 1910.120	*	*		

Hazardous Waste Operations (HAZWOPER) for TSDF	29 CFR 1910.120	*	*		
Emergency Response to Hazardous Materials Incidents/Hazardous Material Technician	29 CFR 1910.120	*	*	*	
National Environmental Policy Act (NEPA)	NEPA of 1969	*			*
National Historic Preservation Act (NHPA)	36 CFR part 800, 36 CFR part 63, NHPA of 1966	*			*
Archaeological Resources Protection Act (ARPA)	43 CFR 7.7 (4) ARPA of 1979	*			
Native American Graves Protection and Repatriation Act (NAGPRA)	NAGPRA of 1990	*			
Emergency Planning and Community Right-to-Know (EPCRA)	EPCRA/SARA 1986 Title 3, Executive Order 12856	*	*	*	*
Lead Based Paint	Lead Based Paint Exposure Reduction Act of 1992, 24 CFR 35	*	*	*	*
Asbestos	40 CFR part 763, 40 CFR 61 part M	*	*	*	*
Endangered Species Act (ESA)	ESA 1973 as amended, 50 CFR par 402	*			*
Clean Water Act (CWA)	CWA S 311	*	*		*
Storm Water Pollution Prevention Planning	CWA S 319	*	*	*	
CFC/Halon Refrigerants	EO 11051, 40 CFR 82.40, 40 CFR 282, 58 FR 92 (p. 28660)		*	*	*
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	FIFRA of 1972, 40 CFR 265.16, SARA of 1986		*		
Solid Waste Management	40 CFR 240-257/RCRA Subtitle D	*			*
Underground Storage Tanks	40 CFR part 280, RCRA Subtitle I	*			
National Pollutant Discharge Elimination System (NPDES)	CWA of 1990, 40 CFR 122-129	*	*		*
Confined Space Entry	29 CFR 1910.146	*	*	*	*
Occupational Respiratory Protection	29 CFR 1926.58, 29 CFR 1910.134	*	*		
Occupational Exposures to Bloodborne Pathogens	29 CFR 1910.1030	*	*	*	*
Storm Water Compliance	40 CFR 122-129, WPCA S 319	*	*		
Hazard Communication Standard	29 CFR 1910.1200	*	*	*	*
Department of Transportation	49 CFR172.704	*	*	*	*

ENVIRONMENTAL COMPLIANCE OFFICER RESPONSIBILITIES

I-21. Field artillery battalions will appoint an Environmental Compliance Officer (ECO)/Hazardous Waste Coordinator. This individual is an excellent source for guidance with regards to environmental regulations and procedures. Appointed personnel:

- Should receive formal training and act as an advisor on environmental regulatory compliance during training, operations, and logistics functions.
- Will be the commander's eyes and ears for environmental matters, as the Safety Officer/NCO is for safety matters.
- Should function as the liaison between the unit and higher headquarters regarding environmental matters such as training requirements, equipment, or supplies that unit personnel need.
- Should inspect HM/HW accumulation sites, and ensure that soldiers handling these materials are properly trained.

- Ensure the unit's SOP covers environmental considerations, conservation, natural resources, pollution prevention, HM/HW, and spill procedures.
- Support the Army's pollution prevention/recycling program.
- Report hazardous material and waste spills immediately.
- Conduct environmental self-assessments or internal environmental compliance assessments, and meet with key installation environmental points of contact, as necessary, to remain updated on any regulatory changes.

SECTION IV – ENVIRONMENTAL RISK MANAGEMENT

ENVIRONMENTAL RISK MANAGEMENT

I-22. Leaders at all levels are required to make timely and appropriate decisions regarding the environment. The failure to do so may negatively impact the training environment, which could then lead to personal liability of individuals directly involved, the chain of command, and the US Army. Therefore, leaders must have a method of managing, assessing, and reducing environmental risks.

THE FIVE-STEP PROCESS

I-23. Risk management is a five-step process designed to provide leaders a methodology for the identification, assessment, control, and evaluation of environmental risks. The following is a summary of these steps from FM 20-400, *Military Environmental Protection,* and FM 100-14, *Risk Management*, refer to them for detailed information.

I-24. **Step 1.** Identify Hazards - Environmental hazards include all activities that may pollute, create negative noise-related effects, degrade archeological/cultural resources, or negatively affect threatened or endangered species habitats. A select listing of common environmental hazards is located in Figure I-3.

Media Area	Common Environmental Hazards
Air	Equipment exhaust, convoy dust, range fires, open-air burning, pyrotechnics/smoke pots/smoke grenades, part-washer emissions, paint emissions, air-conditioner/refrigeration CFCs, HM/HW release, pesticides, other toxic industrial chemicals or material.
Archeological and cultural	Maneuvering and digging in sensitive areas, disturbing or removing artifacts, demolition/munitions effects, HM/HW spills.
Noise	Low-flying aircraft (helicopters), demolition/munitions effects, nighttime operations, operations near post/camp boundaries and civilian populations, vehicle convoys/maneuvers, large-scale exercises.
Threatened and/or endangered species	Maneuvering in sensitive areas, demolition/munitions effects, especially during breeding seasons, disturbing habitat or individual species, HM/HW spills or releases, poor field sanitation, improper cutting of vegetation, damage to coral reefs,

Soil (terrain)	Over use of maneuver areas, demolition/munitions effects, range fires, poor field sanitation, poor maneuver-damage control, erosion, troop construction effect, refueling operations, HM/HW spills, maneuver in ecologically sensitive areas such as wetlands and tundra, industrial waste runoff, pesticide accumulation in soil, vegetation, and terrestrial organisms.
Water	Refueling operations near water sources, HM/HW spills, erosion and unchecked drainage, amphibious/water-crossing operations, troop construction effects, poor field sanitation, washing vehicles at unapproved sites.

Figure I-3. Common Environmental Hazards

I-25. **Step 2.** Assess Environmental Hazards to Determine Risk - A risk assessment is a tool used for evaluating the most pressing or most hazardous potential environmental damage. It considers two factors; probability, how often a hazard is likely to occur; and severity, the effect in degrees a hazard will have on personnel, equipment, environment, and mission. Unit leaders should conduct risk assessments before conducting any training, operations, or logistical activities that are not previously addressed in the SOP, or when conditions differ significantly from the SOP. Complete information on risk assessments can be obtained from FM 20-400 for procedures on how to perform an environmental risk assessment.

I-26. **Step 3.** Develop Controls and Make a Decision - This step is designed to reduce the probability or severity of each hazard, which in turn lowers the overall risk. Control types fall in the categories of educational, physical, or avoidance. Figure I-4 outlines examples of environmental controls, and Section II above contains the specifics pertinent to the met section.

Control Type	Environmental-Related Examples
Educational	• Conducting unit environmental-awareness training • Conducting an environmental briefing before deployment • Performing tasks to environmental standards • Reviewing environmental considerations in AARs • Reading unit's environmental SOPs and policies
Physical	• Providing spill-prevention equipment • Establishing field satellite-accumulation site and procedures • Policing field locations • Practicing good field sanitation • Posting signs and warnings for off-limit areas
Avoidance	• Maneuvering around historical/cultural sites • Establishing refueling and maintenance areas away from wetlands and drainage areas • Crossing streams at approved sites • Preventing pollution • Limiting noise in endangered and threatened species habitats

Figure I-4. Environmental-related Controls

I-27. **Step 4.** Implement Controls - Leaders must inform subordinates of risk-control measures, state how each control is to be implemented, and assign

responsibilities. They must also ensure these controls are in place prior to the operation. This is accomplished by using the *before*, *during*, and *after* checklists and the environmental risk-assessment process. Examples of checklists can be obtained from TC 5-400, *Unit Leaders' Handbook for Environmental Stewardship*, or from the field artillery environmental handbook referenced in Section I, in order to determine the environmental considerations that may effect met section training and operations.

I-28. **Step 5.** Supervise and Evaluate - Leaders should monitor controls to ensure effectiveness and whether controls require modification. They should ensure the after action review (AAR) process includes an evaluation of environmental-related hazards, controls, soldier performance, and leader supervision.

GLOSSARY

Section I
Abbreviations

A	
admin	administration
AI	area of interest
ALSO	artillery limited surface observation
AMV	area of met validity
AO	area of operation
AR	Army regulation
ARTEP	Army training and evaluation program
ASI	additional skill identifier
ASL	Atmospheric Science Laboratory
AFW	Air Force Weather
B	
BILI	basic issue list items
BITE	built-in test equipment
C	
C2	command and control
C	Celsius
cdr	commander
C-E	communications-electronics
CECOM	Communications-Electronics Command
C/I	command/intelligence
comm	communications
COMSEC	communications security
COSCOM	corps support command
corr alt	corrected altitude (Table 2 computation work sheet)
CPL	corporal
D	
DA	Department of the Army
DCT	Digital Communications Termi-nal
DDT	digital data terminal
DISCOM	division support command
divarty	division artillery
DNVT	digital nonsecure voice terminal
DP	dew point
DS	direct support
DT	data-time group
E	
E	east
EA	edit atmosphere (MDS command)
ECCM	electronic counter-countermeasures
F	
F	Fahrenheit
FA	field artillery
FATDS	Field Artillery Tactical Data System
FCE	fire control element
FDC	fire direction center
FEBA	forward edge of the battle area
FLOT	forward line of own troops
FM	field manual
FMH	federal meteorology handbook
FOMET	fallout met message
FSCL	fire support coordination line
FSC	federal supply catalog
FSCOORD	fire support coordinator
FSE	fire support element
G	
gm/m3	grams per cubic meter
GMT	Greenwich mean time
GPS	global positioning system
GRI	grid repetition interval
GS	general support
H	
HAZMAT	hazardous materials
HMMWV	high-mobility multipurpose wheeled vehicle
HQ	headquarters
Hz	hertz
I	

ICAO	International Civil Aviation Organization
intel	intelligence
IPB	intelligence preparation of the battlefield

K

K	kelvin
kHz	kilohertz
km	kilometer
KVA	kilovolt ampere
kw	kilowatt

L

LCPL	lance corporal
log	logistics
LORAN	long-range aid to navigation
LST	local standard time

M

m	meter
ma	milliamperes
MAC	maintenance allocation chart
mb	millibar
MDP	meteorological datum plane
MDS	meteorological data system
mech	mechanized
met	meteorology
METT-T	mission, enemy, terrain, troops, and time available
MHG	meteorological hydrogen generator
Mhz	megahertz
MOS	military occupational specialty
MSDS	material safety data sheets
MSE	mobile subscriber equipment
msg	message
MSL	mean sea level
MMS	meteorological measuring set

N

N	north
NATO	North Atlantic Treaty Organization
NAVAID	navigational aid
NBC	nuclear, biological, chemical
NCO	noncommissioned officer
NOTAM	notice to airmen

O

OPORD	operation order
ops/F	operations/fire (radio net)

P

PFC	private first class
PIBAL	pilot balloon
PLL	prescribed load list
PMCS	preventive maintenance checks and services
POL	petroleum, oils, and lubricants
press	pressure (Table 2 computation work sheet)
PSI	pounds per square inch
PSY	physchological
PSYOP	psychological operations
PTM	plaintext message

Q

QSTAG	quadripartite standardization agreement

R

RC	reserve component
RDF	radio direction finding
RDT	remote data terminal
RH	relative humidity
RPV	remotely piloted vehicle

S

SB	supply bulletin
SC	supply catalog
sel alt	selected altitude (Table 2 computation work sheet)
SF	standard form
SFC	sergeant first class, surface (LED display)
SGT	sergeant
SINCGARS	single-channel ground and airborne radio system
SOI	signal operating instructions
SOP	standing operating procedure
SPC	specialist

SOWT	special observation weather teams
SPU	system processing unit
SSG	staff sergeant (Army)
SSGT	staff sergeant (USMC)
sta ht	station height (Table 2 computation work sheet)
STANAG	standardization agreement
std	standard
STP	soldier training publication
SUPREP	supplementary surface weather report
SWO	staff weather officer

T

TA	target acquisition, MDS command to output to the page printer the met data collection tables for each atmospheric zone
TACFIRE	tactical fire direction system
TACSOP	tactical SOP
TB	technical bulletin
TC	training circular
temp	temperature (Table 2 computation work sheet)
TFT	tabular firing tables
TM	technical manual
TOC	tactical operations center
TRADOC	US Army Training and Doctrine Command
TSOP	tactical standing operating procedure

U

UAV	unmanned aerial vehicle
US	United States
USAF	United States Air Force
USCG	United States Coast Guard
USN	United States Navy
USNWS	United States National Weather Service
UTM	universal transverse mercator (grid)

V

v	volts
V	voice (radio net)
vAC	volts alternating current
vDC	volts direct current
VHF	very high frequency
VLF	very low frequency
V/O	VLF and/or Omega

W

W	West
WB	white bag
WETM	weather team
WLR	weapons-locating radar
WMO	World Meteorological Organization

Z

Z	ZUZU time zone

Section II
Definitions

air mass - an extensive body of air within which the conditions of temperature and moisture in a horizontal plane are essentially uniform

air pressure - the weight of the air per unit of volume

air-weather - the ability to be functional without regard to weather

ambient temperature - the temperature of the immediate surrounding medium, such as a gas or liquid

anemometer - the general name for instruments designed to measure the speed (or force) of the wind

aneroid - literally, "not wet," containing no liquid; applied to a kind of barometer which contains no liquid; an aneroid barometer

antibuoyancy bracket assembly - the assembly that opposes the normal buoyancy (or upward thrust) of the hydrogen generator and charge when they are submerged in water during the hydrogen generation process

azimuth - a horizontal direction expressed in degrees or mils measured clockwise from a known reference point or direction, normally true north

ballistic meteorology - the study dealing with the phenomena of the atmosphere and its effect upon the motion of projectiles

ballistics - the science of the motion of projectiles

ballistic temperature - an assumed temperature that would have the same total effect on a projectile during its flight as the varying temperatures actually encountered; reported as a percent of standard

ballistic wind - a assumed constant wind that would have the same total effect on a projectile during its flight as the varying winds actually encountered

barometer - an instrument for measuring atmospheric pressure

baroswitch - a pressure-operated switching device used in a radiosonde

climatological information - that information which deals with weather conditions and variations from normal, for a particular place or area, during a specified period of a year. Visual temperature and density data are developed from climatological data.

critical angle - the limiting angle at which angular data may become invalid

cursor - an indicator on a computer

density - mass per unit volume, measured in grams per cubic meter

deviations - departures from accepted policies or standards. Ballistic densities and temperatures are reported as deviations from the standards that were used to develop the weapons firing tables.

downwind - the direction toward which the wind is blowing; with the wind

dry-bulb temperature - the temperature measured by the dry bulb of a psychrometer; ambient air temperature

elevation - the measure of height with respect to another point of the earth's surface; usually mean sea level; station elevation

elevation angle - the angle between the horizon and objects above the horizon measured along the arc which passes through the zenith and the object in question

equation of state - an equation relating temperature, pressure, and volume of a system in thermodynamic equilibrium

fallout - the precipitation to earth of particulate matter from a nuclear cloud; also applied to the matter itself which may or may not be radioactive

free lift - the net upward force required for a balloon to rise at a given rate. Free lift corresponds to the specific balloon (sounding or pilot balloon) being used and is a portion of total lift.

fronts -in general, a transition zone between air masses of different densities and temperatures

geopotential height - the height of a given point in the atmosphere in units proportional to the potential energy of unit mass (geopotenital) at this height, relative to mean sea level. Geopotential height is calculated internally by MDS/MMS for the WMO met message

horizontal distance - the arc distance or the distance traveled by a balloon as projected to the earth's curved surface

hydrostatic equation - the basic force equation which states that the change of pressure with respect to height is equal to the negative product of density and the acceleration of gravity

hygristor - a humidity-sensing element or device; a resistor whose resistance varies according to the amount of moisture in the air

inversion - a layer of atmosphere where the temperature increases rather than decreases with height

isobar - a line of constant pressure

isobaric - of equal or constant pressure

isotherm - a line of constant temperature

isothermal - of equal or constant temperature

kelvin scale (°K) - an absolute temperature scale with a freezing point of 273.16°K and a boiling point of 373.16°K

lapse rate - the rate at which temperature changes with altitude

low-level winds - winds in the friction layer of the atmosphere

magnetic declination - the angle between gird or true north and magnetic north

mandatory level - one of several constant-pressure levels in the atmosphere for which a complete evaluation of data derived from upper air observation is required. The mandatory pressure levels are at 1,000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10, 7, 5, 3, 2, and 1.

mean sea level - the average height of the sea surface based on hourly observation of tide height on the open coast or in adjacent waters which have free access to the sea

mean sea level pressure - station pressure reduced to mean sea level pressure

meteorological datum plane - the altitude of the met station from which all met computations are based

meteorological day - a 24-hour day divided into three periods - night, afternoon, and transition

meteorological information - information concerned with the phenomena of the atmosphere; data pertaining to the atmosphere - especially wind, temperature, air density, and pressure which are used to produce met messages for using units.

meteorology - the study of the earth's atmosphere

millibar - a unit of pressure convenient for measuring atmospheric pressure

modulator - that part of a radiosonde which contains the sensing elements and baroswitch

N units - a unit of refraction; a math simplification designed to replace rather awkward numbers involved in the values of the index of refraction

offset - the difference in distance and azimuth from a tracking point to the point of release of a sounding or pilot balloon

Omega - type of NAVAID

operational response - data entered during the operation of the flight

optical-electrical bearing clock - a check performed to ensure that the optical axis of the telescope is parallel to the electrical axis of the RDF

orographic - of, pertaining to, or (frequently in meteorology) caused by mountains

parameter - a quantity to which arbitrary values may be assigned, such a temperature, density, or pressure values

pilot balloon - a small balloon whose ascent is followed by a theodolite to obtain data for computing speed and direction of winds in the upper air

precipitation - form of water, either liquid or solid, that falls from the atmosphere, and which reaches the ground

pressure gradient - the spacing between lines of constant pressure, or isobars

pressure gradient force - the initiating force which produces wind

projectile - any object projected by exterior force and continuing in motion by its own inertia

psychrometer - an instrument used for measuring atmospheric humidity that consists of a dry-bulb thermometer and a wet-bulb thermometer

radioactive fallout - the eventual descent to the earth's surface of radioactive matter placed in the atmosphere by atomic or thermonuclear explosion (also called radiological fallout)

radio direction finder - A component of the MDS/MMS that tracks the radiosonde signal.

radiological fallout - See radioactive fallout.

radiosonde - a balloon-borne instrument (radio) that measures and transmits meteorological data

rawin - a method of winds aloft observation; that is, the determination of wind speed and direction in the atmosphere above the station by using radar or a radio direction finder; a contraction of radio winds

rawinsonde (radiosonde and wind sounding, combined) - a method of upper air observation consisting of the evaluation of winds, temperature, pressure, and relative humidity aloft by means of a balloon-borne radiosonde tracked by a radio direction finder

relative humidity - the ratio of the actual vapor pressure of the air to the saturation vapor pressure, usually expressed in percent

sounding - measurement of atmospheric data by a balloon-borne radiosonde, which transmits these data to an RDF

sounding balloon - a free, unmanned balloon carrying a radiosonde to sound the upper air

sound ranging (sound locating) - the method of locating the source of a sound, such as that of a gum report or a shell burst, by calculations based on the intervals between the reception of the sound at various previously oriented microphone stations

spatial validity - the space, or distance, from the location of the met section that is estimated or determined to be within the valid limitation of the met sounding

standard ballistic density - the density of the air as defined by the ICAO standard atmosphere; density of 100 percent

standard height - the height above surface to the top of a prescribed standard zone

station pressure - surface pressure at the observing station; the atmospheric pressure computed for the level of the station elevation

surface wind - the wind speed and direction as measured at the surface with an anemometer

temperature element - a thermistor which is a resistor that reacts to temperature changes

theodolite - an optical instrument which consists of a sighting telescope and graduated scales to read angles of azimuth and elevation

thermistor temperature - the temperature measured by the temperature element (thermistor) on a radiosonde

total lift - the weight (grams) of the balloon with attachments that must be balanced by the gas volume in the inflated balloon for the balloon to rise at a desired rate of ascent

trajectory - the path of a projectile in the earth's atmosphere

true north - the direction from any point on the earth's surface toward the geographic north pole

virtual temperature - in a system of moist air, the temperature of dry air having the same density and pressure as the moist air. The virtual temperature is always greater than the actual temperature.

visual technique - the determination of upper air conditions from PIBAL observations and the measurement of surface temperature, pressure, and relative humidity

weather forecast - a prediction of expected weather conditions at a point, along a route, or within an area, for a given time or specific period of time in the future

weather information - information concerning the state of the atmosphere, mainly with respect to its effects on the military; data and information concerned with forecasts, summaries, and climatology

weighing off - a balloon inflation procedure when using an inflation shelter which involves inflating the balloon with attached weights in the inflation shelter until it just lifts off the ground and remains suspended in air

weighing factors - the factors used in weighting the effects of met conditions in each artillery zone

wet-bulb depression - the difference in degrees between the dry-bulb temperature and the wet-bulb temperature

wet-bulb temperature - the temperature measured by the wet bulb of a psychrometer; used to determine wet-bulb depression

wind chill - that part of the total cooling of a body caused by air motion

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INDEX

A

B

C