CHAPTER 1

GENERAL

1-1. Purpose. The purpose of this manual is to provide criteria and guidance for the design of buildings in arctic and subarctic regions. This manual supplements TM 5-852-1/AFR 88-19, Volume 1.

1-2. Scope. This manual presents specialized design criteria for existing environmental conditions. These criteria pertain to the building proper and to interior utilities. Other manuals which pertain to arctic and subarctic construction are:

TM 5-852-1/AFR 88-19, Volume 1, Arctic and Subarctic Construction: General Provisions.
TM 5-852-2/AFR 88-19, Volume 2, Arctic and Subarctic Construction: Site Selection and Development.
TM 5-852-4/AFM 88-19, chapter 4, Arctic and Subarctic Construction: Foundations for Structures.
TM 5-852-5/AFR 88-19, Volume 5, Arctic and Subarctic Construction: Utilities.

1-3. Conceptual planning considerations. The facility's basic functional needs must be provided, while total costs are minimized. Particular attention must be given to the harsh environmental stresses, the material availability, the transportation methods to the site, the amount and skill of the available labor force, the relatively short construction season, and conditions under which material will be stored and the facility erected. Constraints that personnel and logistics problems pose to operation and maintenance of remote facilities must be considered. Three primary criteria should be observed: the system must be reliable; easy access for routine and emergency operation and maintenance must be provided; and the system must be as simple as possible. Under harsh environmental conditions, especially in emergency situations, complexity often dooms a system to failure.

a. Morale. Personnel morale, an important but difficult to define factor, must be carefully considered during design. During the long winter, with little daylight and little contrast between land, sea and sky, the monotony can have a negative influence on personnel conduct and efficiency. Comfortable living quarters need to incorporate the creative use of warm, inviting colors and textures. Spatial requirements in excess of those used in the contiguous United States are sometimes necessary. At remote sites, the station becomes the total environment for personnel for sustained periods. Therefore, it may be appropriate to provide individual rooms for the permanent staff, plus single, double or multiple occupancy rooms for visitors. Additional personnel may be required for summer maintenance and emergency winter help. Rooms must be available for those persons. Additional recreational space usable for games, reading, and hobbies is required to counteract the effects of excessive confinement. Many larger remote sites contain a gymnasium and bowling alley, plus separate lounges for officers, noncommissioned officers, and enlisted personnel. Of equal importance to morale are proper temperature control and soundproofing. When personnel are essentially confined to quarters because of the environment, proper temperature for both living and sleeping areas is a major psychological influence. Soundproofing to provide quiet areas will also have a major psychological impact.

b. Multiple-building concept. Originally construction at remote sites usually consisted of many single-function structures, often connected by enclosed passageways. Such facilities occupy large acreages. There are large roof and exterior wall surfaces to maintain which lose heat to the exterior. Thus, large capacity heating systems are required. If there is a central plant, extensive distribution systems are needed. Some enclosed passageways require heat and maintenance but provide limited benefits. Advantageously, however, many small, single-function buildings do not require mechanical ventilation and can be placed on simple, standard foundations which tolerate more foundation movement. Such buildings can minimize fire losses and be constructed more easily on uneven terrain. Standard designs can frequently be site adapted. The multiple-building concept provides adaptability for rearrangement, expansion, or an addition of functions. In cold weather there are psychological advantages in being able to get away from living and working areas by walking in the covered passageways. The multiple-building concept is shown in figure 1 - 1.

c. Composite building concept. Combining functions into a single composite building should be considered, especially for remote areas and small installations. Since a composite building has a greater volume-to-surface-area ratio, initial construction costs are usually lower, heating is less expensive, and maintenance requirements are reduced. Central heating reduces one fire hazard, but the possible loss of the

Figure 1-1. Tin City Air Force Station, Alaska, prior to 1968 (note the multiple buildings connected by long covered walkways).

entire facility by fire, and the number of potential fire sources, dictate higher fire protection requirements and additional safety measures. A composite structure generally contains fewer roof and wall penetrations than do separate buildings, thus reducing the maintenance associated with snow infiltration, leaks, and vent icing. Utility systems often cost less initially, are less likely to freeze or be damaged by differential settlement, and are easier to operate and maintain. The multistory vertical construction achievable with composite buildings can reduce risks for two high cost, high problem areas: roofs and foundations. Since individual site requirements mandate different combinations of functions and needs, a standard design is usually not available for the composite building, necessitating a greater design effort. High noise and hazard areas should be isolated from offices and quarters. Generators should be as far from residential areas as possible, and exhausted on the downwind side of the facility. Downwind direction may vary with the weather and time of year, but is especially critical during the winter storms when the exhaust could infiltrate the building. Exhaust location, therefore, should be planned with the winter storm season in mind. Composite structures make rearrangement of existing functional areas, expansion of functions, or addition of new functions difficult. Two separate but connected buildings should be considered to allow residential areas to be isolated from power generation and equipment maintenance areas to reduce noise and petroleum odor impacts on personnel and to provide shelter in case of fire in one structure. All support and utility systems should be redundant to assure mission accomplishment and safety. A composite building is shown in figure 1-2.

d. Building operation during replacement. Space shortage and/or operational need may result in a requirement that facilities and buildings being replaced remain in operation during construction. As the replacement structure is frequently adjacent to existing facilities, the Contractor's activities and scope of operations are restricted by this requirement. Detailed planning, scheduling, and coordinating become very important.

Figure 1-2. Tin City Air Force Station Composite Building.

1-4. Environmental factors and considerations. Climatic, hydrologic, topographic, and geographic factors influence overall site selection (see TM 5-852-2/AFR 88-19, Vol. 2) and are also important considerations in establishing the configuration of individual structures. Since the environment desired within buildings is usually drastically different from ambient arctic and subarctic conditions, severe stresses are placed on building components. Rapid deterioration and costly maintenance are inevitable unless these stresses are carefully considered when selecting construction materials. Personnel must also be considered when designing for the environment. Poor visibility caused by whiteouts, fog or darkness, coupled with high winds and cold temperatures make it essential to minimize personnel confrontations with the environment. Additional space may be necessary to house functions that can be accomplished outdoors in temperate zones. Enclosed walkways, as shown in figure 1-3, may be necessary if structures are spread out.

a. Climatic conditions. Because of the range and severity of arctic and subarctic conditions, knowledge of *individual* site conditions is particularly important to develop effective methods and procedures for facility design, construction, operation, and maintenance. Temperatures at the Tin City Air Force site in Alaska, for example, range from -44 to + 71° F, with a design wind speed of 110 miles per hour (mph) and design ground snow load of 97 pounds per square foot (psf). Some important climatic factors and ways those factors need to be considered are given in table 1-1.

TABLE 1-1. INFORMATION ON CLIMATE.

Climatic Factors	Areas of Consideration
Temperature	
Mean	General guideline development
Maximum	Material selection and performance
Minimum	Heating system design
Seasonal Variation	Construction planning
Relative Humidity	
Seasonal variation	Condensation control
Wind	
Peak gust	Structure placement & orientation
Prevailing	Structural design ventilation
Seasonal variation	Snow drifting potential
Rain	
Total	Siding materials
Maximum	Roof drainage
Seasonal variation	Roof maintenance season
Snow and Ice	
Snow accumulation	Roof design
Ice accretion	Powerline loads
Drift potential	Building orientation
Seismic Probability	Structural design
Daylight/Darkness	Lighting design

(1) *Problems caused by snow drifting.* Placing utility distribution systems in or below walkways facilitates repair. Walkways, unfortunately, tend to box in a camp and aggravate snow drifting problems. Blowing snow is an important consideration because large drifts may rapidly develop on and around structures, and construction materials left on the surface can be buried by a single storm. Dry windblown

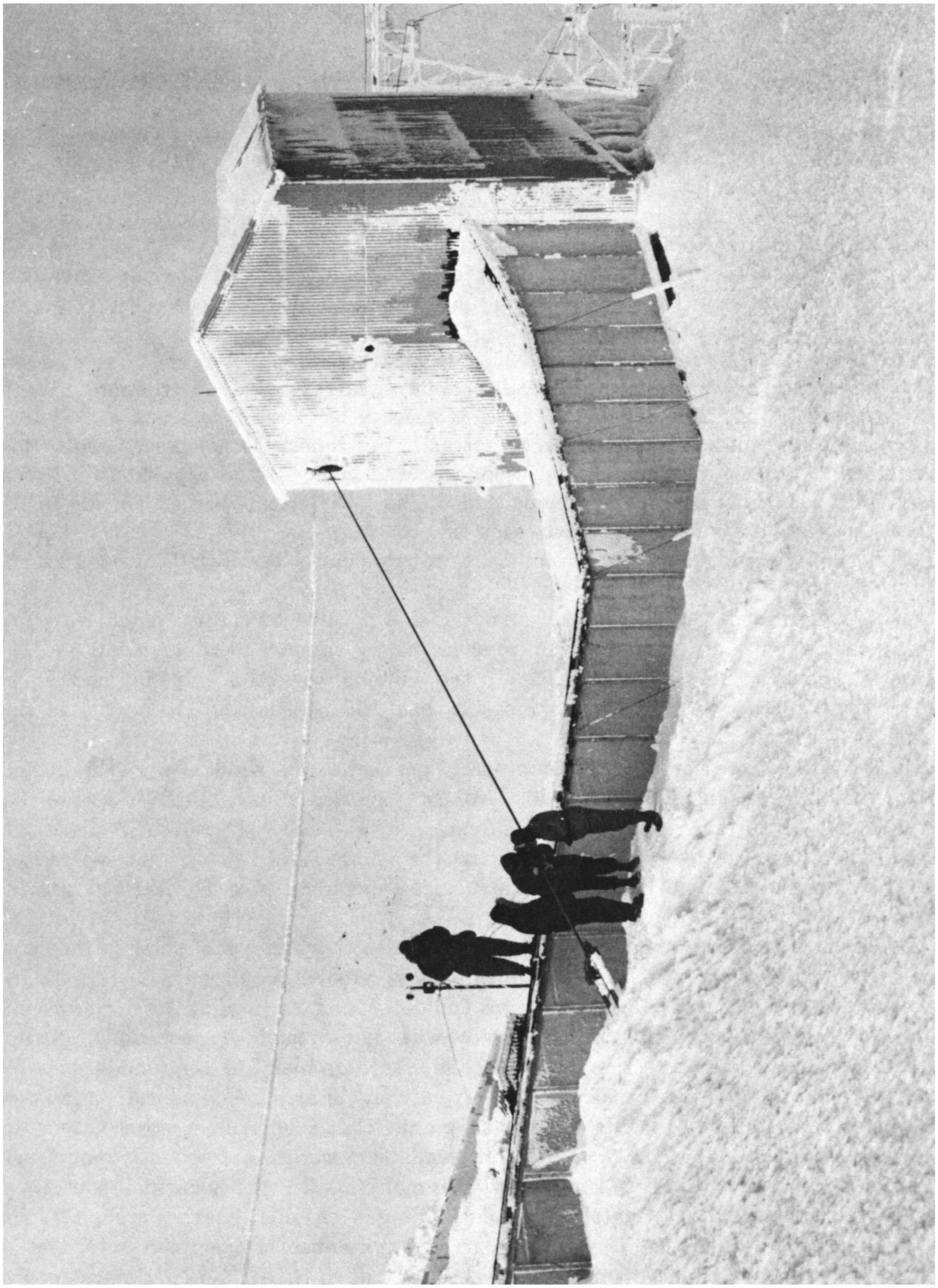

Figure 1-3. Covered walkway at Cape Newenham Air Force Station, Alaska (note the guys used to anchor the walkway against high winds.

snow can enter small cracks in doorways, windows, or louvers intended for ventilation. Generator intakes are occasionally blocked, and warm exhaust stacks and vent pipes coated with ice. Large snowdrifts can accumulate on low roofs and in other areas of "aerodynamic shade." In permafrost areas, snow infiltration in ventilated foundations can be a serious problem. Material and equipment must not be stored adjacent to or under buildings elevated above permafrost since that can result in snow drifts which allow soil warming in winter. Observing site conditions gives important indicators of potential snow drifting problems, and aerial photographs are quite valuable. Weather records should also be consulted to determine the intensity, direction, variability, and frequency of storms and prevailing winds. At one site, prevailing winds may be responsible for most drifting; at another, occasional storms may generate the most problems. It is not uncommon for snowdrifts to cover doorways (see figure 1-4). Winter site visits can be very valuable.

(2) *Solutions to snow drifting problems.* Drifting patterns are difficult to predict but the following guidelines will help minimize problems:

(a) Use trees, shrubs, snow fences or other obstructions to precipitate snow before it reaches the site proper. Where storms may come from any direction, provide protection from all quadrants.

(b) Place major roads parallel to the prevailing wind direction.

(c) Do not locate roads directly upwind or downwind of large obstructions. Where possible, maintain 100-foot upwind and 200-foot downwind clearances.

(d) Locate parking lots alongside roads to act as buffer zones. Do not place parking lots among buildings. Expect additional snow accumulation around parked vehicles, and provide ample room for snow storage away from roads and on the downwind end of the lot. Because curbed islands hinder snow removal operations, they are not suitable in most cases.

(e) Parking aprons should be placed alongside, not upwind or downwind, of hangars and garages.

(f) Orient surface structures with their longest side parallel to the *winter storm wind.* Winter storm winds may come from a different direction than prevailing summer or winter winds.

(g) Doors are best located along the sides of the building, toward the upwind end. Doors on the downwind end of the structure may be rapidly blocked with drifting snow: those on the upwind face are difficult to seal.

(h) Orient large garage doors so they are nearly parallel to the wind, even if this results in a building orientation that is perpendicular to the wind. Adjust this orientation slightly to assure that the doors are not in the lee of the upwind corner of the building.

(i) Place structures in rows perpendicular to the wind. Allow enough space between buildings to permit effective snow removal. Each row of structures should be placed directly downwind from the preceding row.

(j) Provide snow dumping areas to eliminate large piles or windrows of snow in the camp area. Piles and windrows are obstructions which increase future snow removal requirements.

(k) Avoid decorative earthen berms around buildings and in parking lots. Berms can cause additional snow accumulation problems and interfere with snow removal operations, disrupt building access for maintenance and fire protection, and create moisture problems at the foundation wall.

(3) *Sources of climatic information.* Due to the relatively brief developmental period and sparse population, long-term climatological records are primarily unavailable. Short-term observations are often incomplete and may be misleading. Extrapolation of available records is frequently necessary. Governmental agencies are generally the best source of information with the principal source for worldwide data the National Climatic Data Center, Federal Building, Asheville, North Carolina 28801. Much of the information available at Asheville is supplied by the Environmental Science Administration (ESA). DOD agencies should request climatic information through the U.S. Air Force Environmental Technical Application Center (ETAC), Building 159, Navy Yard Annex, Washington, DC 20333. TM 5-785/AFM 88-29 contains information obtained at military sites.

1-5. Cost Factors. Many cost factors must be evaluated to provide a cost effective design.

a. Labor. Skilled labor is usually in short supply locally, so costs are high. Minimizing skills needed and scheduling work to occupy each worker's time fully will reduce total work time. Providing housing

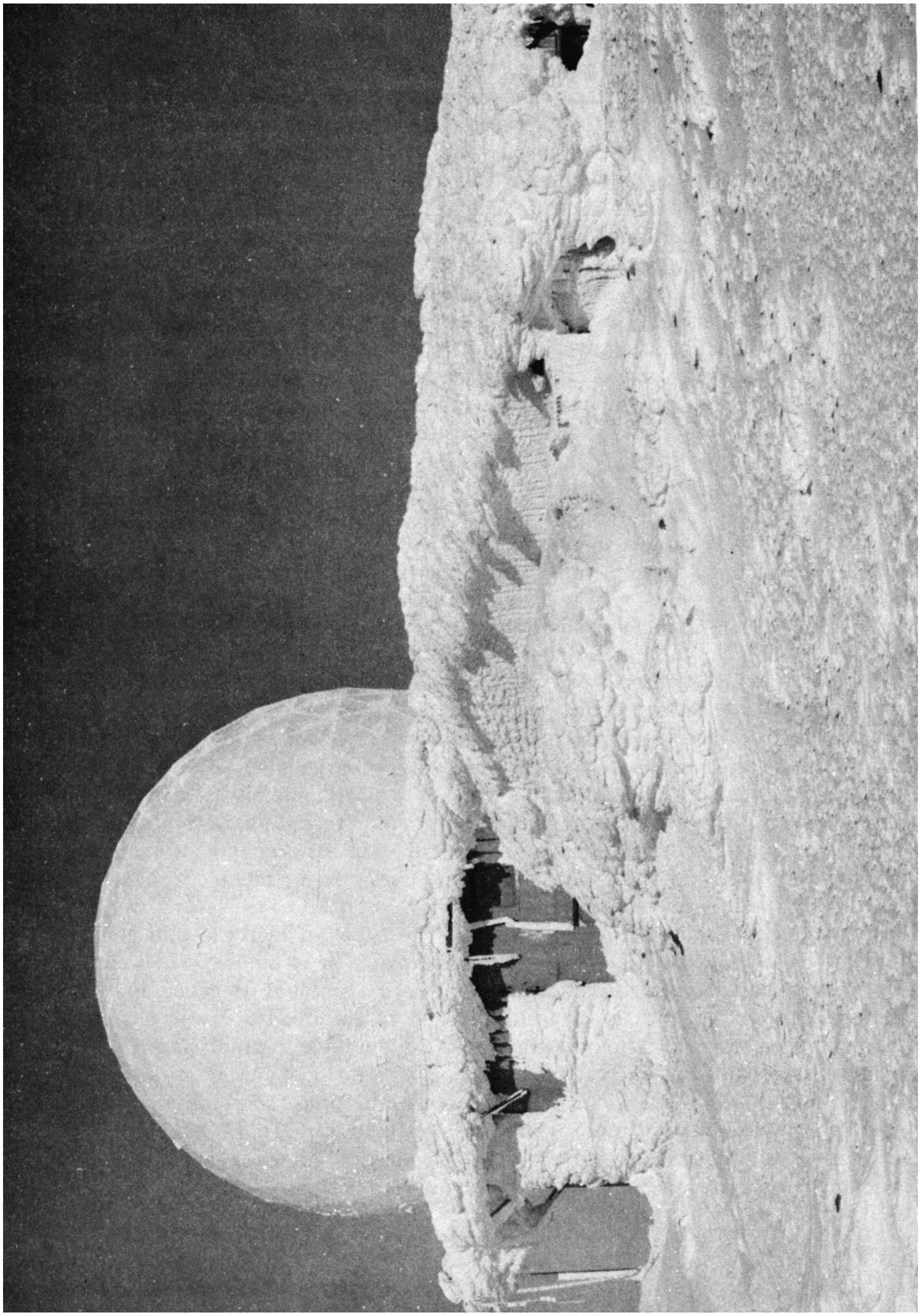

Figure 1-4. Cape Newenham Air Force Station, Alaska, in winter (note the entrances that are unusable because of snow accumulations.)

and meals increases costs in remote areas, therefore, optimum use of work time assumes an even greater importance. Summer months of almost continuous daylight contrast to winter months of almost complete darkness. That variation in daylight and darkness becomes more extreme as one goes farther north. Consequently, long summer work hours are appropriate to take advantage of the daylight and minimize idle time.

b. Materials. Generally, maximum factory prefabrication is most economical. Such savings can be lost, however, because of higher handling and shipping costs. Possible damage and breakage en route could influence a decision to utilize onsite construction. In many areas, common construction materials are unavailable. Sand, gravel, cement, or water for concrete may have to be transported long distances. Suitable timber products, especially piling, may not be locally available, as timber quality and size in the arctic is usually less than that of other areas. Transporting costs for large or heavy construction equipment can become a major portion of the construction cost in remote areas. Eliminating the need for such equipment, or combining separate buildings to utilize special equipment more fully, will reduce overall cost. Delays in shipping equipment can result in prolonged construction time, expensive emergency air freight costs, or unsatisfactory job site improvisation. In coastal areas, prefabricated construction should be considered more seriously as the materials or buildings can be shipped or barged and unloaded on a beach near or adjacent to the site. A short construction season sometimes dictates prefabricated construction. During the design stage, it must be kept in mind that damage to, or loss of, an important building component can postpone the completion date until after the next shipping season. This is especially true if prefabricated components cannot be airlifted to the site or duplicated onsite. If such problems occur, project construction costs may be increased and the facility completion jeopardized, particularly if existing buildings were disposed of in the interim.

c. Maintenance. Since it is desirable to reduce high maintenance costs, the designer must consider whether a high initial cost will be outweighed by decreased maintenance costs, resulting in a lower total cost. Maintenance costs are high due to high local wages, scarce skilled local labor, necessity for providing room and board at remote locations, difficulties, costs, and risks in shipping materials and equipment, decreased efficiency of men and machines due to environmental conditions, and the length and cost of communications and re-supply channels.

1-6. Scheduling. Work scheduling must utilize the least expensive transportation methods. During ice-free periods, the most economical means is usually by water, on rivers and northern seas. Materials will not arrive until ice breakup at the site, however, unless icebreakers or ice-strengthened vessels are available. Planning to utilize full barge loads will reduce costs, since barge charges are fixed by the rental cost of the barge and towing vehicle. Scheduling all work at a particular site under one contract can cut transportation costs. During the winter, transportation over frozen land, rivers, lakes, and marshes where there are no roads or rivers may be more economical than air transportation. Because of short construction seasons, outside work must be accomplished quickly. Scheduling work so that the structure can be closed in during mild weather, with interior work done during severe weather, will expedite completion, reduce costs, and eliminate many problems. The types of material and construction method used will be impacted by the length of the construction season. For example, cold weather may limit concrete work, while prefabricated-type construction could still proceed. Because of the short construction season and soil conditions, the first year is often used to establish a camp, clear the site, move required materials into the area, construct foundations, and do whatever prefabrication is possible; the second season is then used for actual building construction. For additional information on seasonal work scheduling, see TM 5-852-4/AFM 88-19, chapter 4. The optimum time for shipping construction materials and supplies coincides with the optimum time for construction. This factor may require expensive air delivery of construction materials used early in the project, or a longer completion time when cost is the most important consideration.