

DOCUMENT RESUME

05515 - [B0945850]

Status of the Air Force's Missile X Program. PSAD-78-35; B-163058. March 31, 1978. 14 pp.

Report to the Congress; by Elmer B. Staats, Comptroller General.

Issue Area: Federal Procurement of Goods and Services: Definition of Performance Requirements in Relation to Need of the Procuring Agency (1902); Science and Technology (2000).

Contact: Procurement and Systems Acquisition Div.

Budget Function: National Defense: Weapon Systems (057).

Organization Concerned: Department of the Air Force.

Congressional Relevance: House Committee on Armed Services; Senate Committee on Armed Services; Congress.

The Missile X (MX) system is an advanced, highly accurate, mobile intercontinental ballistic missile system the Air Force is developing. Its increased survivability, as compared to the fixed-in-place Minuteman system, is intended to be gained by having a number of possible missile launch points. The Air Force is considering buried trench and shelter basing concepts for deployment of the MX. Findings/Conclusions: Complete data may not be available to support an October 1978 MX full-scale development decision review. When concept validation was approved in 1976, the Air Force was asked to reduce the magnitude and uncertainty of cost for certain MX subsystems and to demonstrate technical feasibility. For several areas specified for examination, information will not be available until October 1978, and information on the cost of constructing the buried trench will not be complete until well after October. The results of these efforts must be evaluated to propose the most cost-effective design to meet operational requirements. Considering the cost magnitude and technical risks involved in the MX program, scheduling the full-scale development decision should be contingent on the availability of accurate and complete results of advanced development efforts. (RRS)

5906

REPORT BY THE U.S.

General Accounting Office

Military Construction Standards Should Be Updated To Better Meet User Needs And Save Money

Although most of the Department of Defense's construction standards are comprehensive and flexible, some should be improved. Lighting and air-conditioning standards conflict with Federal energy conservation goals. Insulation criteria do not suit some local climates, and sometimes, structural standards exceed local building codes and weather conditions. Facilities are built in Hawaii with unneeded air-conditioning.

The problems are caused by Defense's delaying in updating construction standards and not adequately considering suggestions by field personnel. GAO recommends improvements for standards which will reduce facility construction and operating costs.



LCD-77-351

APRIL 3, 1978



UNITED STATES GENERAL ACCOUNTING OFFICE

WASHINGTON, D.C. 20548

LOGISTICS AND COMMUNICATIONS
DIVISION

B-180960

The Honorable
The Secretary of Defense

Dear Mr. Secretary:

This report discusses the need to update military construction standards to better suit certain climatic conditions and energy conservation standards, and to reduce certain construction costs in such cases.

This review was made because we noted many discrepancies between construction and energy conservation standards while working at various Pacific-area military installations on another review.

This report contains recommendations to you on pages 9, 16, and 17. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the Acting Director, Office of Management and Budget; the Chairmen, House Committee on Government Operations, Senate Committee on Governmental Affairs, House and Senate Committees on Appropriations, and House and Senate Committees on Armed Services; and the Secretaries of the Army, Navy, and Air Force.

Sincerely yours,

A handwritten signature in cursive script, appearing to read "F. J. Shafer".

F. J. Shafer
Director

GENERAL ACCOUNTING OFFICE
REPORT TO THE SECRETARY OF
DEFENSE

MILITARY CONSTRUCTION
STANDARDS SHOULD BE UPDATED
TO BETTER MEET USER NEEDS
AND SAVE MONEY

D I G E S T

GAO reviewed selected military construction standards for outside the continental United States as specified by the Department of Defense. GAO found that

--some policies and standards were not suitable for (1) certain climatic conditions, (2) Defense agencies' requirements in the Pacific area, or (3) certain energy conservation standards and

--construction costs were increased unnecessarily in such cases.

Revised lighting design standards allow intensities in excess of current conservation standards. The cost of installing standard military office lighting can be about 40 percent more than lighting designed to meet conservation standards. (See pp. 3 to 5.)

Also, Defense's air-conditioning design standards allow lower temperatures than those authorized by Federal conservation regulations. The result varies with individual circumstances, but the design can affect the size of the air-conditioning unit required. (See pp. 5 to 7.)

Defense's insulation standards primarily are based on heating system losses in cold and Temperate Zone climates and, therefore, are not suitable for designing air-conditioned space in warm climates. (See p. 7.)

Structural standards are not always based on local conditions. Buildings on Guam are designed to withstand 155-mile-per-hour winds. In Okinawa, where maximum

wind velocities are lower, buildings are designed to withstand 180- to 185-mile-per-hour winds. Also, Army and Air Force criteria for required roofload capability can exceed regional codes. (See pp. 7 and 8.)

Some of these problems are caused by Defense's delay in updating its criteria manual and not considering specific suggestions by field personnel. (See pp. 8 and 9.)

Defense's policy has not been sufficiently flexible for conditions in Hawaii to allow using less expensive designs that better meet user needs. For example, even though installations and field engineers in this mild climate request no air-conditioning and less insulation, these features are still included. (See pp. 11 to 15.)

The Secretary of Defense should provide the means to

- regularly revise construction standards;
- allow for greater input from users in formulating and revising the standards; and
- compare construction standards with others, such as energy conservation, to assure consistency.

The Secretary should also direct the Army and Air Force to revise their roof-live-load criteria to allow reductions under certain conditions. (See p. 9.)

With respect to Hawaii, the Secretary should reevaluate the present requirements for insulation, vapor barriers, and air-conditioning to better meet local conditions. Where feasible, air-conditioning should be eliminated from designs. (See pp. 16 and 17.)

The Department said this report would be highly valuable since it focused attention on and gave priority to several of Defense's

activities. It agreed with most of GAO's recommendations and said actions have been underway for some time to correct deficiencies. Since these actions are not yet complete, GAO does not know if they will be adequate. (See pp. 10, 17, and 18.)

Defense's major objections and GAO's responses have been included in the report where appropriate.

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ABBREVIATIONS

DOD Department of Defense
F Fahrenheit
GAO General Accounting Office
GSA General Services Administration

CHAPTER 1

INTRODUCTION

Military construction standards are used in designing and building Department of Defense (DOD) facilities worldwide. These standards affect the adequacy of a facility and its costs of construction, operation, and maintenance. We looked at the application of selected standards in the Pacific Ocean area.

The Army Corps of Engineers and the Naval Facilities Engineering Command design and construct major DOD facilities worldwide. Army and Navy engineers must follow standards in the DOD Construction Criteria Manual (DOD Manual 4270.1M), which provides broad technical criteria and policy guidance for constructing facilities that meet user needs at reasonable costs.

Both Army and Navy engineers manage military construction in Hawaii, but construction management in other Pacific areas is usually assigned to a single service. Army and Navy engineers estimated the following major construction workload in fiscal year 1977.

Estimated Army and Navy Engineers' Fiscal Year 1977
Construction in the Pacific (note a)

	<u>Hawaii</u>	<u>Japan</u>	<u>Korea</u>	<u>Phillippines</u>	<u>U.S. Pacific territories</u>	<u>Total</u>
	----- (millions) -----					
Army Corps of Engineers Pacific Ocean Division	\$53	\$10	\$19	\$ -	\$ 3	\$ 85
Naval Facilities Engineering Command, Pacific Division (note b)	<u>39</u>	<u>5</u>	<u>--</u>	<u>c/17</u>	<u>34</u>	<u>95</u>
Total	<u>\$92</u>	<u>\$15</u>	<u>\$19</u>	<u>\$17</u>	<u>\$37</u>	<u>\$180</u>

a/Includes direct costs of military construction but does not include overhead, operational repair, and maintenance construction projects.

b/Includes Johnston Island.

c/Includes Diego Garcia.

The Army and Navy contract for most major construction. Engineering designs are drawn by in-house personnel or by contracted architect and engineering firms. All contractors performing military construction must comply with criteria in the DOD manual.

The DOD manual specifies general criteria for all basic engineering disciplines plus environmental quality, fire protection, military family housing, and other areas requiring special consideration. It also provides varying requirements for unique regional characteristics depending upon environmental and economic factors. The manual is augmented by DOD and military service engineering criteria, regulations, specifications, and special directives. However, all engineering procedures must comply with the provisions in the DOD manual.

SCOPE OF REVIEW

We examined the adequacy and flexibility of the standards prescribed by DOD and individual services. We worked at DOD headquarters, Washington, D.C.; Pacific area headquarters of Army and Navy engineers in Hawaii; and selected locations in Hawaii, Japan, and Guam. We discussed standards with military engineers and user officials of all services, and talked with the National Weather Service and private organizations.

CHAPTER 2

DOD SHOULD UPDATE CONSTRUCTION STANDARDS

DOD's construction standards are generally comprehensive and provide the flexibility to meet varied user needs. Some policies and standards should be revised, however, because they have contributed to user dissatisfaction and unnecessary costs. Although the data obtained dealt with Pacific area facilities, some have broader, and possible worldwide impact. Specific problems pertaining to Hawaii are discussed in chapter 3.

The military services have modified their construction standards to conform with other standards, such as energy conservation. Updating has lagged, however, and sometimes the updated construction standards still conflict with use standards. In other cases, the standards provide insufficient or excessive design.

CONSTRUCTION STANDARDS THAT CONFLICT WITH OTHER STANDARDS

DOD's lighting criteria for general space specifies the intensities recommended by the Illuminating Engineers Society to a maximum of 150 footcandles. The military services set lighting design standards for office space generally at 70 footcandles. DOD requires actual operating intensities to be reduced to Federal energy conservation levels of 50 footcandles. According to DOD, designed intensity can be reduced to conservation levels by installing

- fewer lamps in fixtures,
- multi-level switched ballasts,
- grid-type ceilings with movable lighting fixtures,
and
- lower wattage lamps.

Conservation regulations prescribed by the General Services Administration (GSA) for all Federal agencies specify that overhead lighting during working hours shall not exceed 50 footcandles at work stations, 30 footcandles in other work areas, and 10 footcandles in non-work areas. Therefore, DOD's design standards for lighting office space exceed the conservation standards and result in added costs.

Army and Navy engineers estimate that the cost of installing lights is approximately proportional to the lighting level. For example, the Navy estimates that installing lights to provide 50 footcandles throughout a 31,500-square-foot office costs \$62,500. For 70 footcandles, the costs are \$87,500--a 40 percent increase. Navy engineers in Hawaii estimated that life-cycle costs for 25 years would increase about 60 percent if additional air-conditioning required to compensate for the heat of the lights is considered. This estimate would not apply to areas outside of Hawaii, where heating is required.

Although in its comments on our report DOD acknowledged that initial expense for increased lighting would be greater, it stated that life-cycle costs would not be increased from greater heat load on the air-conditioning systems because lighting intensities are operated at Federal standards. However, our work at 16 military bases on another review showed numerous examples where lighting was operated in excess of Federal conservation standards. This would, of course, be precluded by designing lighting to the 50-footcandle GSA operating standard rather than to the 70-footcandle DOD design standard.

In addition, DOD cited the need for flexibility in lighting for varied use patterns of general office space as a justification for designing lighting levels above Federal standards. We disagree because if the maximum level for the best lighted area in general office space--a work station--is 50 footcandles, then 50 footcandles is the highest level needed for normal work in that office, regardless of how the work stations are configured. If a specific unusual task justifies more light, Federal guidelines provide for additional lighting on that task only.

DOD apparently assumes that exceptions to Federal lighting regulations would be so numerous that economies from designing to meet those regulations would be nullified. If this were true, waivers could be granted for specific projects. We still believe, however, that construction standards should be consistent with the use standards.

DOD also expressed concern over the arbitrary use of 50 footcandles and cited other standards. We are aware of differing commercial standards and identify other standards

in our report. Also, in a 1977 report, 1/ we recommended that the Secretary of Energy review the various lighting guidelines and develop national guidelines that could be easily understood and consistently applied in commercial, public, and industrial buildings.

However, pending development of national guidelines, Federal conservation regulations have been promulgated for use by the Government. These regulations do not specify tolerances. Although we are not making an issue of nominal variations, we believe DOD's criteria allowing overall lighting far in excess of Federal standards is not warranted. If DOD does not agree with the established Federal regulations, it should work within the system to resolve its disagreements.

Another construction standard that conflicts with conservation standards is air-conditioning design. Federal conservation regulations require that general office space shall not be cooled below 78° to 80° Fahrenheit (F) and prohibit humidity control during the cooling season. However, DOD construction criteria specify that air-conditioning will be designed to provide inside temperatures of 75° to 78°F, and can be designed to provide relative humidity levels as low as 50 percent.

The capacity of equipment to air-condition a space must be increased as the design temperature and humidity are decreased. Numerous factors affect the amount of cooling capacity needed including: heat gain from roofs, walls, and windows; internal heat from people, lights, and appliances; and humidity (latent heat) from inside sources and outside air.

The table on page 6 shows the difference in air-conditioning capacity required for various interior temperature and humidity specifications of an Army dining hall design in Korea.

1/"Federal Agencies Can Do More To Promote Energy Conservation By Government Contractors," EMD-77-62, Sept. 30, 1977.

Specifications for
interior temperature
and relative humidity

Relative percentage
of air-conditioning
capacity required

75° F at 50%	132%
75° F at 60%	118%
80° F at 70%	100%

Although DOD design criteria for cooling does not authorize an interior temperature above 78°F, military and commercial design recommendations exceed that level, indicating that higher levels may be reasonable. Military engineers in Guam told us that designing for higher inside temperature and humidity could even result in more comfortable average conditions, because the air-conditioning equipment would operate with fewer "off" periods, thus maintaining a more constant and lower humidity.

DOD's comments on air-conditioning design discuss the DOD standards in greater detail but do not dispute the fact that construction criteria allow air-conditioning system designs larger than needed to meet energy conservation standards. With regard to humidity control, DOD said that (1) its 50-percent criterion is a minimum, (2) there is no prescribed maximum, and (3) specific humidity control is generally not provided for office space. (See pp. 23 and 24.) We note, however, that DOD criteria do allow providing additional air-conditioning capacity simply to reduce humidity.

DOD also stated that the Federal Energy Administration has no criticism of direct humidity control if waste heat is used, since no new energy is required for this effort. We disagree with DOD's interpretation of this matter because even if waste heat is used for reheating, additional energy is required for air-conditioning. To illustrate this, assume that workers want to reduce the relative humidity in an office because it is too high, even though the temperature is an acceptable 75°F. To reduce the relative humidity, they use air-conditioning and, as a result, the temperature is lowered to 70°. To compensate for the drop in temperature, waste heat given off from the air-conditioning system is used to raise the temperature back to 75°. The net effect of this is a reduction in the relative humidity and a temperature remaining at the same level. Although it may be true that new energy was not required to raise the temperature back to 75°, new energy was required to initially lower the temperature to 70°. Further, it is conceivable that additional energy would also be required to redistribute the waste heat from the air-conditioning system to the office space.

Also, Federal regulations prohibit humidity control, regardless if waste heat is used, in general office space unless waivers are obtained. Federal regulations and Federal Energy Administration guidelines provide that humidity control for peculiar uses or locations may be considered on a case-by-case basis. Guidelines further state that use of heating energy other than waste heat for such cases should be avoided.

In addition, DOD did not concur that designing for higher inside temperature and humidity could result in more comfortable average conditions. However, military engineers in Guam told us that since air-conditioning systems are designed for peak rather than average loads, actual interior temperature under average conditions would not necessarily rise as stated by DOD.

CONSTRUCTION STANDARDS THAT ALLOW EXCESSIVE OR INSUFFICIENT DESIGN

DOD's standards for building insulation are primarily based on heating system losses in Temperate Zone climates that range from -40° to $+50^{\circ}$ F. These standards are unsuitable for warm climates where only air-conditioning is provided. As a result, there is inconsistent application of the standards in tropical locations. For example, insulation and vapor barrier criteria are prescribed for family housing in Hawaii but not for Guam, where officials said humidity is a serious problem. An indication of the problem's severity is reports of mildew from too much humidity even in air-conditioned space in Guam. Service engineers have stated that reducing humidity infiltration from the outside could help alleviate this problem in Guam. However, as discussed on pages 15 and 16, the prescribed insulation and vapor barrier criteria for Hawaii may be excessive.

Structural standards permit variances depending on conditions at a particular location. As described below, however, we found that in one case, DOD standards exceeded historical experience and in another instance, service requirements were higher than those of local building codes. There seemed to be no reasonable explanation for these variances.

Military service design criteria for winds which a building must withstand require 160- to 185-mile-per-hour capability in Okinawa. However, the criteria for Guam, which we were told experiences higher winds than Okinawa, requires only 155-mile-per-hour capability. Officials on Guam stated that experience as recent as the May 1976 super typhoon Pamela has shown the 155-mile-per-hour requirement to be sufficient.

Army and Navy engineers estimated that the increased structural cost for a given pre-engineered building in Okinawa could range from about 6 to 12 percent. Service officials stated they had no specific data on how the wind requirements for Okinawa had been determined, but that this will be included in an ongoing study of related standards.

Army and Air Force criteria for required roofload capability is 20 pounds per square foot. Although Navy criteria and a code used in Hawaii require the same basic roof-live-load capability, they allow reductions to as little as 12 pounds per square foot under certain conditions. The Army and Air Force criteria, however, do not provide for such reductions. Navy engineers estimated that pre-engineered roof support construction cost for a 30- by 100-foot area would decrease about 33 percent if the design roofload decreased from 20 to 16 pounds per square foot.

In its comments on our report, DOD stated that the 20-pounds-per-square-foot standard is considered suitable for relocatable structures but it can be reduced for other types of buildings. Army and Air Force criteria, however, preclude such reductions.

SYSTEM TO UPDATE CONSTRUCTION STANDARDS CAN BE IMPROVED

The construction criteria manual has not been updated on a 2-year cycle as desired by DOD. Also, we noted that specific suggestions by field personnel were not always adequately considered, or were delayed or lost in the system.

Although there is no written requirement to do so, DOD headquarters officials responsible for construction standards and design told us the construction criteria manual should be updated on a 2-year cycle. Because only four professional staff members are assigned to monitor DOD-wide facility design and construction matters, they have not met their self-imposed updating goal. They said means, such as ad hoc tri-service committees, are used to spread the workload, but this has not provided sufficient support.

DOD emphasized in its comments that these tri-service committees have been fully responsive and highly valuable. While this may be true, they have not been sufficient to update the construction criteria manual as desired.

Some potential changes or updates to the standards do not come to the attention of appropriate DOD personnel. Examples are shown below.

- An Army engineer stated he had suggested that the aforementioned wind requirement criteria for Okinawa be revised several years ago, but was never answered.
- An Air Force engineer's suggestion to exclude hot water pipes and faucets from buildings where hot water is not planned was rejected by Air Force headquarters. The rejection cited an Occupational Safety and Health Administration regulation without explaining its relevance.

CONCLUSIONS AND RECOMMENDATIONS

Construction standards have a far-reaching and long-lasting effect on the initial construction costs and on the operation and maintenance costs over the life of a facility. Although DOD's construction standards are generally comprehensive and flexible, certain improvements can be made.

Conflicting and outdated standards contribute to increased cost and may run counter to the Government's energy conservation goals by providing a facility with too much lighting and cooling or too little insulation and vapor barrier protection.

We recommend that the Secretary of Defense provide the means to

- regularly revise construction standards;
- allow for greater input from users in formulating and revising the standards; and
- compare construction standards with others, such as energy conservation, to assure consistency.

The Secretary should also direct the Army and Air Force to revise their roof-live-load criteria to allow reductions under certain conditions.

AGENCY COMMENTS AND OUR EVALUATION

We provided draft copies of this report to DOD for comment; DOD generally agreed with our recommendations. (See app. I.) DOD's comments and our evaluation have either been incorporated into the body of the report or are discussed below and on page 17 as appropriate.

DOD stated that it has had actions underway for some time that will provide implementation of our recommendations. However, since these actions are not yet complete, we do not know if they will be adequate.

DOD expressed concern that the report describes it as being unresponsive to the recent energy shortage. This report addresses construction standards, and no inference is intended as to DOD's overall energy program.

CHAPTER 3

LESS COSTLY DESIGNS ARE POSSIBLE IN HAWAII

In Hawaii's unique climate, less expensive designs for cooling can be used, which meet user needs better than standard designs. But military policy is not flexible enough to take advantage of these opportunities, and facilities are built with possibly excessive insulation and unneeded air-conditioning.

DESIGNS DO NOT TAKE ADVANTAGE OF NATURAL VENTILATION

A National Weather Service official told us temperature and humidity are seldom extreme in Hawaii and the cooling winds usually ameliorate any adverse effects except in certain locations. Hawaii's construction industry has developed techniques to take advantage of the cooling winds, such as: large eaves, flow-through ventilated attic space, building cross ventilation, and special site orientation and landscaping. The techniques are not necessarily unique to Hawaii but, because of the mild environment, they are fully developed and consistently used.

We discussed the necessity of Hawaii air-conditioning with design engineers, architects, and base facility engineers. Most said that by using applicable design techniques, air-conditioning would not be necessary in most military facilities. Exceptions would be certain special purpose facilities, such as hospital operating rooms and facilities where aircraft noise is a problem.

Most new Hawaiian military facilities include air-conditioning

In 1974 we reported ^{1/} that air-conditioning military family housing in Hawaii is unnecessary and that DOD's mandatory criteria was inappropriate. The Congress subsequently restricted using appropriated funds for air-conditioning family housing in Hawaii. The restriction provided that the Secretary of Defense could permit use of air-conditioning in extenuating circumstances. DOD complied with the restriction, but does not apply the principle to other facilities.

^{1/}"DOD's Requirement for Air-Conditioning Military Family Housing in Hawaii is Unnecessary," B-172376, May 20, 1974.

Because of unsuccessful attempts to modify designs, Army and Navy engineers are designing facilities in Hawaii with what they consider to be unnecessary air-conditioning. Sixteen of 19 recent Corps of Engineers projects have partial or total central air-conditioning, including a church, a dining facility, administrative areas, bachelor living quarters, and family homes. 1/ Buildings not air-conditioned include an automotive craft shop at Schofield Barracks and a hazardous cargo facility at Hickam Air Force Base.

A Navy design for a dining facility at Pearl Harbor included air-conditioning even after repeated objections by the installation commander. He requested natural ventilation through floor-to-ceiling louvered windows and repositioning the building to take advantage of prevailing trade winds. The Pacific engineering command reported that the agreement in the final design review conference was that air-conditioning would remain as designed, except for providing some windows that open. Navy engineers in Hawaii also attempted to exclude air-conditioning from a naval communications station facility, but their proposal was denied.

The Army recently built a centrally air-conditioned dining facility at Schofield Barracks. The facility is completely enclosed and unable to take advantage of the consistently mild weather at Schofield, one of the highest elevated and coolest military installations on Oahu. The 25th Infantry Division Command officials told us air-conditioning is rarely, if ever, needed at Schofield. For example, the commander's office is centrally air-conditioned, but his staff reported that the system is seldom operated except where rooms are completely closed off from outside air.

An Air Force chapel now under construction will have an enclosed, centrally air-conditioned sanctuary and will not take advantage of trade winds. Army engineers believe that air-conditioning the chapel is questionable. We contacted over 20 churches near military installations in Hawaii to discuss the need for air-conditioning; we found only one church that was air-conditioned.

1/The Secretary of Defense determined that air-conditioning for a 2,600-unit housing complex being built by the Corps of Engineers in the crater of an extinct volcano near Honolulu was needed because the crater blocked the cooling winds.

Most church representatives stated that air-conditioning is a luxury and not necessary if there is good natural ventilation. Army engineers told us local churches are much less expensive to build than military chapels because of this.

DOD said in its comments that the sanctuary's temperatures could rise to uncomfortable levels at the Air Force chapel because the sanctuary could be used as many as four times in a morning. Our review of planning and construction data for this project disclosed requirements for an air-conditioned facility, but no analysis of environmental and use factors to determine the need for air-conditioning. Specifically, we found no data on the expected temperatures in the sanctuary if it had been designed for natural and/or mechanical ventilation. We cited this and others as cases where military officials in Hawaii questioned the need for air-conditioning, and further analysis would, in our opinion, have been appropriate.

Although DOD's criteria does not require Hawaiian facilities to be air-conditioned, local Army and Navy engineering officials said that standard designs without significant adaptation do not provide sufficient ventilation; consequently, air-conditioning is needed. Headquarters organizations, such as the Assistant Secretary of Defense (Installations and Housing), the services' chief medical officers, and chief chaplains approve standard designs for facilities under their administration. Deviations from criteria and designs require their approval. Local military engineering officials told us that because waivers are very difficult to obtain, they are reluctant to request them.

A standard design for bachelor quarters at the Marine Corps Air Station, Kaneohe Bay, included air-conditioning. To eliminate air-conditioning, Navy engineers proposed a new design with modified cross ventilation, site orientation, and landscaping. The engineers believed their concept offered greater livability at less cost than the standard design.

DOD disapproved the proposal and recommended that air-conditioning bachelor quarters be continued. The disapproval stated that flow-through natural ventilation might be marginally acceptable but that air-conditioning was preferable for comfort. It also said the proposed design exceeded space-per-man limitations and that even:

"* * * if an acceptable room layout could be developed for flow-through natural ventilation at the Kaneohe site, it would be expected by many critics of Defense expenditures that the existing [bachelor quarters] at Kaneohe be converted to mechanical ventilation."

Navy engineers in Hawaii said DOD's response showed inadequate analysis of their proposal.

DOD headquarters officials told us they cannot specifically require air-conditioning but can disapprove inadequate designs. Apparently, DOD considers the lack of air-conditioning in Hawaii as inadequate design.

Using air-conditioning is costly

In our May 1974 report, we pointed out that installing central air-conditioning in military facilities is expensive. The initial cost of air-conditioning selected facilities is shown in the following Corps of Engineers' estimates.

Army Reserve Center, Fort DeRussy	\$350,000
Army Reserve Center, Hilo	50,000
Aviation facility, Wheeler Air Force Base	52,000
Chapel, Hickam Air Force Base	80,000
Commissary store addition, Schofield Barracks	228,000
Consolidated dining facility, Schofield Barracks	117,000

The Navy Area Audit Service recommended in September 1975 that air-conditioning the six bachelor enlisted quarters at Marine Corps Air Station, Kaneohe Bay, be eliminated at a savings of \$1,800,000 initially and \$442,000 annually thereafter. The Air Station facility engineer supported the Audit Service's position. He told us the additional installation and maintenance costs of air-conditioning and the station's limited maintenance budget were the main factors for his position.

The Hawaiian Electric Company, U.S. Army Support Command, Hawaii, and the Corps of Engineers estimated the energy to air-condition the 2,600-unit housing project currently being built by the Corps of Engineers would be about 10 times greater than the energy needed for mechanical ventilation. The utility estimates that the project will use over 78 million kilowatt hours annually.

DOD objected to our comparison of energy needed for air-conditioning as opposed to mechanical ventilation on the grounds that we did not state that the mechanical ventilation would be only a supplement to natural air movement. This was, of course, implied in the comparison. The cited comparison is made in the project's Environmental Impact Statement which states:

"The power requirements for mechanically ventilated units would be 354 [kilowatt hours] per month for the project, or about 10 percent of an air-conditioning load. Thus, about 2.85 [megawatt hours] of energy will be saved by not air-conditioning these units."

Further, we recognize that natural ventilation is a factor in cooling and address it in our recommendations.

INSULATION CRITERIA MAY REQUIRE EXCESS INSULATION FOR AIR-CONDITIONED BUILDINGS

DOD criteria requires that air-conditioned space in Hawaii be insulated. Although the requirement for Hawaii is less than that in other regions, it may still be excessive.

DOD requires foil-backed gypsum board over a furred space in all air-conditioned space in Hawaii, regardless of the wall material used. According to DOD, this serves as a heat and humidity barrier. Commercial practice in Hawaii is to add the additional wall only for appearance, and it is not normally installed in concrete masonry structures.

Army engineers and a Hawaiian Electric Company official told us that heating--not cooling--is the major requirement for insulation, and since there is no heating requirement in Hawaii, there is less need for insulation. In a 1974 study of insulation requirements in Hawaii, ^{1/} we reported that private and military engineers believed that, because of the relatively mild contrast between inside and outside temperatures in Hawaii, DOD's requirement was excessive. Because of the minor variance between inside and outside temperatures, only minimal amounts of heat and humidity enter through walls. Therefore, energy savings of added insulation and vapor barrier are small.

^{1/}Letter report to Congresswoman Mink, B-180960, July 9, 1974.

DOD officials disagreed with this but local Army, Navy, and private engineering officials believe it is true. Army engineers suggested revising the insulation requirement, but DOD and Army engineering headquarters turned it down. Local engineers believe they are in the best position to determine the proper requirements consistent with energy conservation and local environmental factors.

In commenting on our report, DOD stated that our discussion on heating, cooling, and insulation and the lack of any necessity for insulation in Hawaii for air-conditioning is not technically correct. The comment appears to result from a misinterpretation of the report. We referred to the need for less insulation; we did not feel that there should be no insulation at all.

CONCLUSIONS AND RECOMMENDATIONS

Although DOD criteria appears generally comprehensive and flexible, more local input into the planning processes and better consideration for unique needs could produce better adapted facilities in Hawaii.

We believe that DOD's criteria for Hawaiian construction do not result in military facilities which meet user needs at the most reasonable cost. Air-conditioning and insulation criteria do not adequately consider the lack of temperature or humidity extremes and the availability of cooling winds. Standard designs are frequently used by DOD which fail to provide the open-air livability features common to privately constructed buildings in Hawaii.

We recommend that the Secretary of Defense, because of the unique conditions in Hawaii

- allow field engineers greater leeway in adapting facilities to local conditions,
- reevaluate the present requirements for insulation and vapor barriers,
- instruct field engineers to review current and future designs to eliminate air-conditioning where feasible,
- refine and clarify DOD air-conditioning criteria to consider natural air movement as a comfort factor, and

--refrain from requiring air-conditioning simply because it is allowed.

AGENCY COMMENTS AND OUR EVALUATION

DOD generally agreed with our recommendations but objected to some statements in this chapter. The comments are included in the body of the chapter or are discussed below, as appropriate.

DOD stated that its policy of requiring a waiver to eliminate air-conditioning is a valuable tool for preventing expensive future modifications, because more waivers are received to add air-conditioning than to omit it. In our opinion, this policy contributes to the apparently excessive air-conditioning in Hawaii, and DOD should refrain from requiring air-conditioning in such climates.

DOD also stated that natural air movement should be considered by the designer of any heating, ventilating, or air-conditioning system. We agree, but point out that DOD's construction criteria manual should be revised to more clearly provide guidance in this matter.



MANPOWER,
RESERVE AFFAIRS
AND LOGISTICS

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

9 NOV 1977

Mr. F. J. Shafer
Director, Logistics and
Communications Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Shafer:

This is in response to your letter of August 28, 1977 to the Secretary of Defense forwarding a copy of your Draft Report "Military Construction Standards should be Updated to Better Meet User Needs and Save Money", (OSD Case 4706).

With regard to the recommendations on pages 9, 10, and 18, we generally agree and we have had actions underway for some time that will provide implementation where required. We cannot agree however with many of the points and statements made in the body of the report. Our detailed comments on the recommendations and the body of the report are attached.

We wish to emphasize that many of the actions we have underway pre-date the issuance of this draft report or the start of the study. Nevertheless the draft report is highly valuable in that it has served to focus attention on and prioritize several of our activities.

Sincerely,

ROBERT B. PIRIE, JR.
Principal Deputy Assistant Secretary
of Defense (MRA&L)

Encl

[See GAO note, p. 26.]

DoD Comments on the Recommendation of GAO Draft Report
"Military Construction Standards Should Be Updated to
Better Meet User Needs and Save Money"

Chapter 2

Recommendation: That the Secretary of Defense provide means to regularly revise construction standards.

DoD Position: Agree. The DoD Construction Criteria Manual is now under revision. Rather than waiting for a complete draft, portions are being circulated for review as available. The next issue will be loose leaf and set up to permit page and paragraph changes as necessary rather than awaiting a complete manual revision.

Recommendation: That the Secretary of Defense allow for greater input from users in formulating and revising standards.

DoD Position: Generally agree. The DoD processes for developing and publishing standards, instructions and directives has always stressed the full coordination and input of affected agencies. Nevertheless, more input is desirable. The DoD Construction Criteria Manual will be fully reviewed by the Military Departments and Defense Agencies, and their comments will be given full weight in its completion. Further, the simplified change procedure described above will permit greater response to user requirements in future revisions. We have noted one basic problem and that is due to a natural parochialism of organization, climatic area and area of responsibility. It is often difficult to obtain a broad suggestion that can be adopted to the overall problem.

Recommendation: That the Secretary of Defense compare construction standards with other standards, such as energy conservation to assure consistency.

DoD Position: Agree. The new edition of the DoD Construction Criteria Manual will contain a chapter specifically addressing energy conservation and we will attempt to have the entire manual integrated and consistent respecting all standards. The DoD has been in the forefront in energy conservation for many years and we expect to continue that position.

Chapter 3

Recommendation: That the Secretary of Defense, because of the unique condition in Hawaii -

-- Allow field engineers greater leeway in adapting facilities to local condition.

DoD Position: The DoD has always considered local conditions to be of prime importance in every design. Overall criteria such as fire safety, quality of construction and life cycle economics must be considered in the light of and be compatible with the aesthetics of the locality, local materials, skills and methods and environmental requirements. This philosophy is expressed in Chapter 1 of the DoD Construction Criteria Manual.

-- Reconsider the need for insulation and vapor barriers.

DoD Position: Concur. At the request of this office the U.S. Army Corps of Engineers has a study underway on the use of vapor barriers in tropical climates. This study should be completed by April of 1978 and criteria will be revised, if necessary, based on its findings.

-- Instruct field engineers to review current and future designs to eliminate air conditioning where feasible.

DoD Position: Air conditioning should be eliminated where it is not necessary. However, the very high cost of adding air conditioning to a building after it is built requires that a very careful study be made before it is omitted from an eligible building. The present requirement that an exception to policy be obtained when it is intended not to include air conditioning in a new building in an eligible area is a valuable tool for preventing expensive future modifications and should be continued. This office rarely receives requests to omit air conditioning but frequently is requested to grant waivers to add air conditioning.

-- Refine DoD air conditioning criteria to consider natural air movement as a comfort factor.

DoD Position: Natural air movement should be considered by the designer of any heating, ventilating and air conditioning system. The designer should also consider many other related factors such as natural obstructions and nearby buildings which could direct or block

natural ventilation. Building orientation and layout are critical to natural ventilation and the site or building use may restrict or prohibit the use of natural ventilation. Privacy, noise control and security are critical elements in evaluation of the use of natural ventilation. In family housing it is normal and reasonable to assume that the adults and teenage children would keep bedroom and bathroom doors closed and hence natural ventilation would be cut off. In a BEQ or a BOQ in a "motel configuration" with a solid wall running the entire length of the building and separating the rooms, natural ventilation to the rooms on the leeward side is not feasible. In one BEQ design proposed for Hawaii, cross ventilation could be achieved only by leaving the bathroom door open and this was not considered reasonable. This design was also interesting in that a considerable portion of the front wall, the source of ventilation air, was solid. In order to achieve privacy it would be necessary to close the window blinds which would seriously curtail natural ventilation. (This case is an example of the value of central review of unusual field designs.)

-- Refrain from requiring air conditioning simply because it is allowed.

DoD Position: The DoD air conditioning policy has been developed carefully over a period of 23 years. With regard to air conditioning for personnel comfort the policy has been and remains conservative. By closely monitoring the use of air conditioning in the private sector, the DoD has attempted to provide its personnel with comparable facilities only after general acceptance by the public. Use of air conditioning in mild climates still lags behind the private sector and other Government agencies. Accordingly, DoD permits air conditioning only where there is a proven and accepted need. The DoD does not permit air conditioning where it is unnecessary. Over the years we have become convinced that the lowest total cost is obtained by installing air conditioning at the time of building construction. The cost of adding air conditioning after construction is excessive and frequently results in systems which are energy intensive.

DoD Positions on the Body of the GAO Report
"Military Construction Standards Should Be Updated
to Better Meet User Needs and Save Money"

General

The general impression given in the GAO report is that DoD has been unresponsive to the recent (since 1973) energy shortage. While the DoD Construction Criteria Manual 4270.1-M requires revision, DoD has been a leader in implementing requirements for energy conservation and cost effective construction. For example, the 1967 DoD criteria required "U" values for walls and roofs of 0.21 and 0.07 respectively. The 1972 criteria reduced these to 0.15 and 0.05 respectively. The 1967 and 1972 criteria required that the 25 year life cycle energy and maintenance costs be carefully evaluated in the initial selection of heating and air conditioning systems. Also, in response to the national recognition of an energy shortage in 1973, OSD promulgated various memoranda to the Military Departments which supplement the DoD Manual. These memoranda provide additional criteria on energy conservation requirements and techniques for use by the military.

Chapter 2

Illumination levels (pages 4 and 5). The DoD criteria currently maintains illumination levels at the GSA standard of 50 footcandles at work stations, 30 footcandles in other work areas and 10 footcandles in non-work areas. However, a 70 footcandle intensity is utilized for design purposes. This requires some additional initial cost for the electrical system in the building, including switching circuits, fixtures, feeders, and transformers. It provides for considerably greater flexibility in building space use, prevents expensive rehabilitation costs to the electrical system to accommodate changed missions and space use patterns and is adjudged as less expensive on a life cycle cost basis. As the lighting intensity is operated at the GSA standard level, the GAO remark on increased life cycle costs due to greater heat load on the air conditioning system is not valid.

Even if DoD lighting levels were operated above the Federal Standard, the statement is incomplete since the life cycle cost would decrease because of the reduced heating load in the winter. When the private sector began to reduce lighting levels, a sharp increase in heating costs was noted. Many engineering and energy conservation authorities have questioned the logic of reducing lighting levels in

areas where electric power is generated from non-critical sources and thereby increasing the use of natural gas and oil for heating.

The DoD is concerned with the arbitrary use of 50 footcandles for all cases. In the FEA guidelines "Lighting and Thermal Operations - Energy Management Action Program for Commercial-Public-Industrial Buildings," a more natural approach to the lighting problem is presented. For example, Table 1 specifies 50 footcandles plus or minus 10, not an absolute 50. Further this table clearly differentiates between "normal office work" and "prolonged somewhat difficult work" (75 fc \pm 15). In addition on page 5 of these guidelines, the statement is made that the difficulty factor is to be multiplied by 1.5 for workers over 50 years of age. If the lighting levels at the task are to be increased because of difficulty of task, age, and other reasonable factors, then the designer must provide circuits, feeders, outlets, transformer capacity, etc. to supply the supplementary lighting. In addition the user must supply task lighting equipment. It would appear that claims for economy for lower levels of general lighting will be more than offset by the requirements for task lighting service and equipment. For example, the provision of under floor electrical raceways on a modular grid to provide electrical outlets for any combination of desk arrangement is a very costly item. The installation and removal of floor outlets with every office rearrangement is also a costly operational item.

Air Condition Design (pages 5 and 6). Federal conservation standards for office buildings are of recent origin and many buildings just completed were designed prior to the issuance of the standards. We are aware of the Federal conservation regulation requiring that general office space not be cooled below 78° Fahrenheit (F) and prohibiting humidity control during the cooling season. Some years ago the standard interior design temperature was 80°F. The capacity of refrigeration equipment is still based and rated upon 80°F dry bulb (DB) and 67°F wet bulb (WB) by manufacturers. The current DoD design temperature condition correlates the inside design temperature with the exterior temperature. The differential to be maintained is 15°F but the inside temperature will not exceed 78°F DB or be less than 75°DB. Hence the DoD maximum is exactly equal to the Federal minimum. DoD criteria states that the relative humidity (RH) will be a minimum of 50% under these design conditions, which indicates a minimum incidental level. The GAO report indicates that DoD criteria specify that the design will provide -- relative humidity levels as low as 50%, which indicates positive levels of control. The GAO report presents an incomplete picture by not explaining the controlling factors specified by DoD. There is no maximum restriction on the designer and he may choose any RH above 50% which would still provide a reasonable comfort level.

We do not concur with the GAO statement "that designing for higher inside temperatures and humidity could even result in more comfortable average conditions, because ---- with fewer "off" periods thus maintaining a more constant and lower humidity." We understand, however, what GAO was attempting to state. Deliberate underdesign of refrigeration capacity would require the air conditioning equipment to operate almost continuously at design temperature conditions (interior and exterior). This would result in a higher inside dry bulb temperature but a more constant RH. This condition results in higher average interior DB temperature and lower average RH conditions at the higher DB temperature. However, control of both would be incidental; and overall operating costs could be higher.

As interior temperatures increase, an increase in humidity rapidly adds to the discomfort level. The DoD would agree that a design level of 78°F DB and 60% RH would be reasonable for a dining hall. However, we seriously question that 80°F DB and 70% RH would be comfortable especially considering the density of people and the high latent loads associated with food service. For the large majority of cases, the DoD does not provide specific humidity control in office spaces. Humidity control is a by-product of cooling and the humidity control noted by the designer is a nominal figure which can increase under certain ambient and load conditions. In a few cases, a specific control of humidity may be included. It is the understanding of the DoD that FEA has no criticism of direct humidity control where "waste" heat from the refrigeration cycle is used for reheat since no new energy is required for this effort.

Insulation and Vapor Barriers (page 7). We have no comment except to reemphasize that the Department of the Army Corps of Engineers is currently carrying out a research project on vapor barriers in tropical areas.

Wind Loading Criteria (page 7). The current design wind velocity requirements for the continental United States and overseas military installations were established by a Tri-Service (Army, Navy, Air Force) committee in April 1974. The specific wind criteria for Guam and Okinawa and other overseas locations were set up by this committee based upon the best information available. This data is currently being reviewed by the three Services, and will be revised as necessary.

Roof Loading Criteria (page 8). The GAO report is referring to roof live load reductions for supporting members based upon the tributary roof area supported. Although not specifically defined in

DoD criteria, it is standard design practice to reduce the roof live load for the design of supporting members based upon the roof slope and tributary area supported. For instance, Navy criteria provides a reduction to 12 psf minimum for girders or trusses carrying the primary roof framing members for large roof areas. Therefore, the 20 psf load may not apply to these members depending on the size of the building. Pre-engineered buildings are considered relocatable and used at various locations, therefore, the minimum load must be suitable for a wide geographic area. A 20 psf roof loading for these facilities has been determined to be the most suitable "standard" loading.

System of Updating Standards (pages 8 and 9). The paragraph is generally correct, however, it tends to give the impression that Tri-Service committees have not provided sufficient support to DoD. This is entirely incorrect as Tri-Service committees on construction standards have been fully responsive and highly valuable. The entire revision system to date has been less than adequate and is being revised. See our comments on the recommendations. In addition each of the Military Departments have systems for encouraging input from their field offices and making full technical evaluations of such suggestions. We cannot comment on the specific examples cited as evidence otherwise since we are not aware of them.

Chapter 3

General

We concur with the report that air conditioning is not necessary in temperate climates where structures can be designed to utilize trade winds to provide suitable human comfort. There are certain locations in Hawaii where both initial and operating costs can be reduced through designs which are specifically developed to take advantage of the trade winds to eliminate the need for air conditioning. We have constructed facilities of this type which have proved satisfactory. However, such designs cannot be utilized throughout Hawaii because of unsuitable terrain, existing construction or other features which would preclude natural ventilation. Therefore, the provision of air conditioning for certain facilities in Hawaii should be optional.

Air Conditioning of Air Force Chapel (page 13). The sanctuary of the Air Force chapel now under construction (Hickam AFB) will be used for as many as four Sunday morning services. Without air conditioning, the room temperature would rise to uncomfortable levels. Based on our knowledge of civilian church operations, it is unlikely

that any of the surveyed unairconditioned churches receive such heavy usage.

Air Conditioning of Family Housing (page 16). The statement that air conditioning for 2600 family housing units would require 10 times the energy necessary for mechanical ventilation, is not concurred in. The comparison is meaningless. If the statement read "10 times the energy for natural ventilation supplemented by mechanical ventilation," it would be more believable.

For instance, if it were possible by mechanical ventilation to achieve similar interior conditions, the energy requirements would be greater than for air conditioning.

Insulation Criteria (page 16). The discussion presented by the GAO report on heating, cooling and insulation and the lack of any necessity for insulation in Hawaii for air conditioning is not technically correct. Insulation and vapor barriers are used to reduce the refrigeration capacity of air conditioning equipment; and it is applied on the principle of achieving the least life cycle cost. However, please note our previous comments on the current study of vapor barrier utilization in tropical climates.

GAO note: Page references in this appendix refer to the draft report and do not necessarily agree with the page numbers in the final report.

PRINCIPAL OFFICIALS RESPONSIBLE FOR ADMINISTERING
ACTIVITIES DISCUSSED IN THIS REPORT

	<u>Tenure of office</u>	
	<u>From</u>	<u>To</u>
<u>DEPARTMENT OF DEFENSE</u>		
SECRETARY OF DEFENSE:		
Harold Brown	Jan. 1977	Present
Donald Rumsfeld	Nov. 1975	Jan. 1977
DEPUTY SECRETARY OF DEFENSE:		
Charles W. Duncan, Jr.	Jan. 1977	Present
William P. Clements, Jr.	Jan. 1973	Jan. 1977
ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS) (note a):		
Dale Babione (acting)	Jan. 1977	Apr. 1977
Frank A. Shrontz	Feb. 1976	Jan. 1977
Dr. John J. Bennett (acting)	Apr. 1975	Feb. 1976
ASSISTANT SECRETARY OF DEFENSE (MANPOWER, RESERVE AFFAIRS AND LOGISTICS) (note a):		
John P. White	May 1977	Present
Carl W. Clewlow (acting)	Jan. 1977	May 1977
<u>DEPARTMENT OF THE ARMY</u>		
SECRETARY OF THE ARMY:		
Clifford L. Alexander	Feb. 1977	Present
Martin R. Hoffman	Aug. 1975	Feb. 1977
ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, LOGISTICS AND FINANCIAL MANAGEMENT):		
Alan J. Gibbs	Apr. 1977	Present
Edwin Griener (acting)	Jan. 1977	Apr. 1977
Harold L. Brownman	Oct. 1974	Jan. 1977

	<u>Tenure of office</u>	
	<u>From</u>	<u>To</u>
<u>DEPARTMENT OF THE NAVY</u>		
SECRETARY OF THE NAVY:		
Wm. Graham Claytor, Jr.	Feb. 1977	Present
Gary D. Penisten (acting)	Feb. 1977	Feb. 1977
Joseph T. McCullen, Jr.	Feb. 1977	Feb. 1977
David R. MacDonald	Jan. 1977	Feb. 1977
J. William Middendorf	June 1974	Jan. 1977
ASSISTANT SECRETARY OF THE NAVY (INSTALLATIONS AND LOGISTICS) (note b):		
Vacant	Jan. 1977	Apr. 1977
Jack L. Bowers	June 1973	Jan. 1977
ASSISTANT SECRETARY OF THE NAVY (MANPOWER AND RESERVE AFFAIRS) (note b):		
Vacant	Jan. 1977	Apr. 1977
Joseph T. McCullen, Jr.	Sept. 1973	Jan. 1977
ASSISTANT SECRETARY OF THE NAVY (MANPOWER AND RESERVE AFFAIRS AND LOGISTICS):		
Edward Hidalgo	Apr. 1977	Present
<u>DEPARTMENT OF THE AIR FORCE</u>		
SECRETARY OF THE AIR FORCE:		
John C. Stetson	Apr. 1977	Present
John C. Stetson (acting)	Jan. 1977	Apr. 1977
Thomas C. Reed	Jan. 1976	Jan. 1977
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS AND LOGISTICS):		
Vacant	Apr. 1977	Present
Richard J. Keegan (acting)	Feb. 1977	Apr. 1977
J. Gordon Kapp	Mar. 1976	Jan. 1977
Frank A. Shrontz	Oct. 1973	Feb. 1976

- a/The position of Assistant Secretary of Defense (Installations and Logistics) was abolished on April 20, 1977, and its functions were divided between the Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs) and the Office of the Director of Defense Research and Engineering.
- b/The Offices of the Assistant Secretary of the Navy, Installations and Logistics and Manpower and Reserve Affairs, were combined into Manpower, Reserve Affairs and Logistics on April 25, 1977.

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