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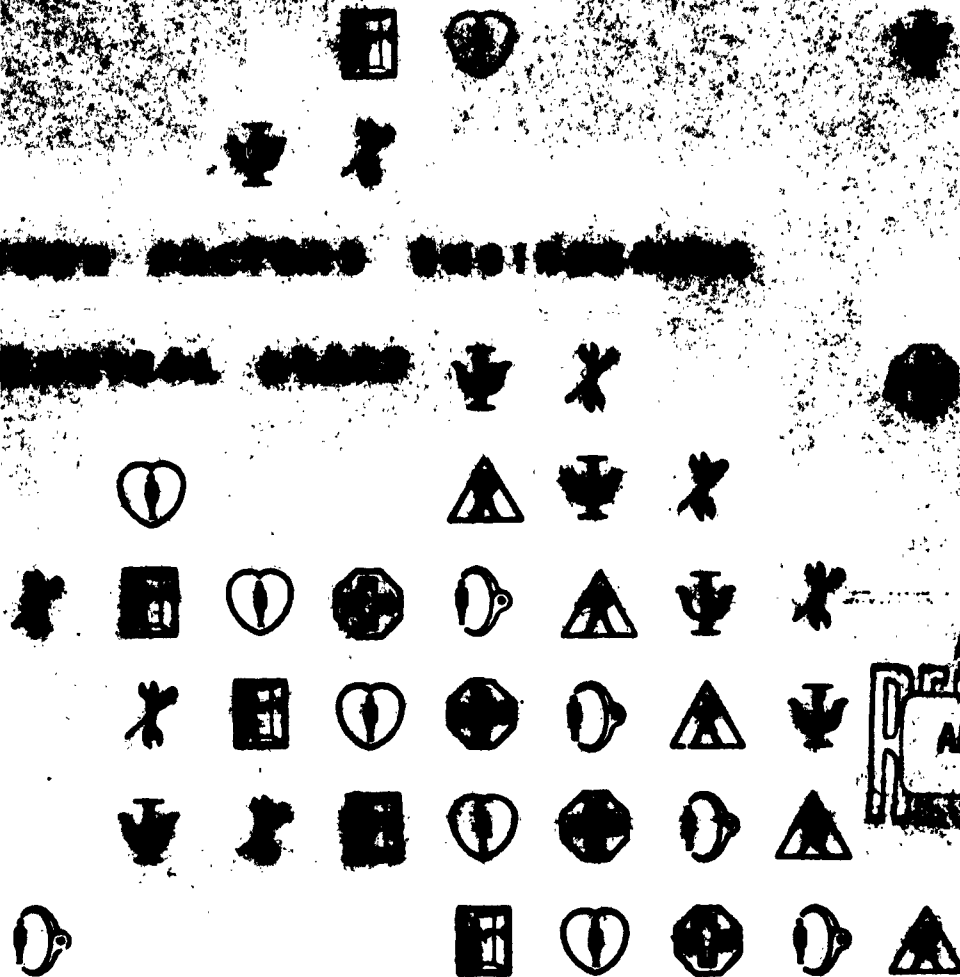
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AMERICAN MACHINE & FOUNDRY COMPANY

GREENWICH ENGINEERING DIVISION

GREENWICH, CONN.

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In 3 Volumes

HUMAN FACTORS ENGINEERING
REVIEW AND EVALUATION OF TITAN WEAPON
SYSTEM 107A-2 LAUNCHER, OSTF & TF-1

FINAL REPORT

Contract No. AF 04(647)-138

The Human Factors Engineering Group
Technical Staff

31 January 1962
Volume II
Chapter 16 - 26

AMERICAN MACHINE & FOUNDRY COMPANY
GREENWICH ENGINEERING DIVISION
GREENWICH, CONNECTICUT

Chapter 16

Human Factors Review and Evaluation
of the
Tug Truck

KEY SWITCH



A key switch prevents unauthorized use of vehicle.

HORN



A horn has been provided to warn personnel of impending hazards.

FIRE EXTINGUISHER

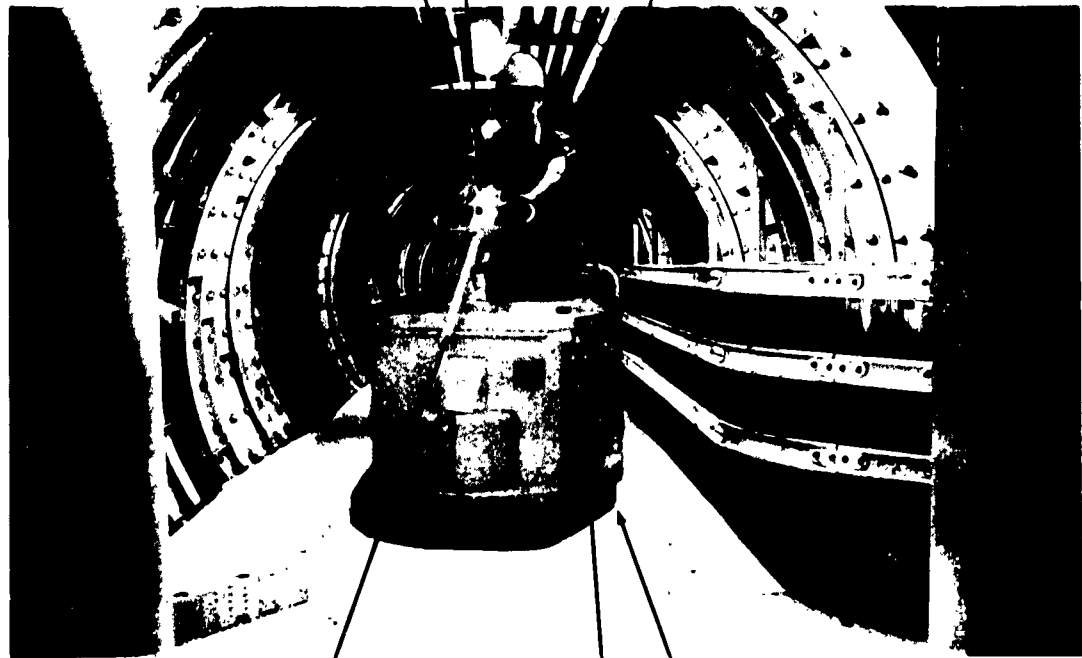


A fire extinguisher should be affixed where it can be easily reached.

SEAT



Provide for safe and efficient seated operation to allow head clearance in low tunnel passages and to reduce accident possibilities.



FAIL SAFE CONTROL



Dead man controls have been provided to improve safety.

HOISTING EQUIPMENT



Handling assistance for removal of heavy batteries should be provided.

STEERING GUIDANCE



Provide a steering guidance system to facilitate tunnel turning & backing.



CONDUCTIVE TIRES



Vehicle is equipped with conductive tires to reduce sparking.

ACCESS OPENINGS



Access for maintenance has been provided.

FIGURE 16-1
HUMAN FACTORS INPUTS
TUG TRUCK

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: TUG TRUCK									
	Human Factor Effort Required	PHASE IN STAGE			HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	OSTF	TF
								OS	SYMBOL
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Competability	*	*	*	*	*	*	*	*	*
1.2 Controls and Displays									
1.3 Fail-Safe Design	*	*			*	*		*	*
1.4 Malfunction Detection									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual									
2.2 Access, Servicing	*	*		*				*	*
2.3 Remove and Replace								*	*
2.4 Handling, Physical Limitations	*	*		*				*	*
2.5 Handling, Transportation								*	*
2.6 Vehicle Maneuverability	*		*	*		*	*	*	*
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination									
3.2 Escape Provisions									
3.3 Protection from Entanglement									
3.4 Protection from Falling									
3.5 Safety Devices (other)	*	*		*	*			*	*
3.6 Warning Devices	*	*		*	*			*	*
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling									
5.4 Fear of Isolation									
5.5 Feeling of Insecurity									
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature									
6.3 Illumination									
7.0 HUMAN USE FACTORS									
7.1 Procedure									
7.2 Time Study									
7.3 Training/Selection									

FIGURE 16-2

1.0 DESCRIPTION

- 1.1 The Tug Truck is a vehicle used for towing the maintenance dolly, the mobile work platform, the flat bed trailers, etc., between the Ready Maintenance Room in the Command Control Center and the missile silo areas via the personnel access tunnels. The Tug Truck is battery powered and controlled through electrical interlocks which provide a dead man safety feature. Power is automatically cut off and the brake is applied when the control handle is released from either operating position. The Tug is capable of pulling a 4,000 lb. load at a speed of 2 to 4 miles per hour while ascending a 5% grade and the battery life is rated at 432 ampere hours.
- 1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate the Tug Truck efficiently within the tunnels without causing damage to equipment or injury to personnel. The vehicle must be designed to provide adequate access to batteries and other parts requiring frequent service, and where maintenance tasks require removal of components heavier than a man can safely lift, special handling devices must be provided. All of these factors contributing to the successful use of the Tug Truck have been itemized on the Summary Checklist (Figure 16-2) and the progress of the Tug Truck design has been tabulated in detail in the following Synopsis.

ITEM: TWO TRUCK									
HUMAN FACTORS		DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS
	CONTINUING ACTION 2.1A		TECH REF		PARTICIPATION	RECOMMENDATIONS	ANALYSIS TEST		
1.0 BULK ENGINEERING DESIGN 1.1 INTEROPERATIVE CAPABILITY	PAL 4.1.1	ASA 453.1 PAL 2.3 ASA-450C PAL 4.1A	VISION OVERHEAD BEING IN DESIGN POSITION IS 77". TWO TRUCK PLATFORM IS 8" HIGH. HAND RIG AREA 1" TO BEING AND SIDE WHEEL AREA 1" TO BEING. THROUGH THE VISION ACCEPTABLE OVERHEAD CLEARANCE IN THE TRUCK SHOULD BE 87". TWO TRUCKS TO BE MADE FROM THE TRUCKS RUNNING INSTALLATION AND AT THE SHALLOW TRAIL APERTURE ALONG THE ROOF.	20-478-7100 1/14/59.	THE VISION TRAIL APERTURE IS AT THE SHALLOW TRAIL BEING THE OVERHEAD BEING IS ONLY 77". IT WAS RECOMMENDED THAT THE INSTALLATION, VISION, OR OVERHEAD AREA BEING 87" BE PAINTED IN ALTERNATE 2" BANDS OF YELLOW AND BLACK STRIPS INCLINED 45° PER ASA 453.1-1953 (REF. 3). THE PROBLEM IS WITH THE BEING AT OR BECAUSE OF DESIGN TRAIL BEING WHICH PLATE LIMITS OVERHEAD CLEARANCE. A TWO TRUCK WHICH WOULD ALLOW THE TRUCKS TO SET UPON WAS RECOMMENDED.	1 1 1 1	THE TWO TRUCKS HAVE BEEN PAINTED FOR RECOMMENDATION PROPOSED CHANGES INCLUDE A RECOMMENDATION TO LOCATE THE OPERATING POSITION OF THE TRUCKS, ALSO INCLINED IS A SEAT TO PROVIDE OPERATOR FROM A FULLY SEATED POSITION.		
1.3 PAIR HAVE DESIGN	PAL 1.1A	ASA 453-1 PAL 4.1	THE TWO TRUCK DESIGN SHOULD BE SUCH THAT UNDER NO CONDITIONS CAN THE TRUCKS BEING WITHOUT AN OPERATION AT THE CONTROLS. THE TWO TRUCK CONTROLS SHOULD HAVE A "TRAIL HAN CONTROLS" FOR THIS PURPOSE.		THE TWO TRUCKS SHOULD BE LARGE WAS A "TRAIL HAN CONTROLS" FEATURE. THIS MEANS THAT WHENEVER THE OPERATOR DOES NOT MAINTAIN PRESSURE IN THE STANDARD PRESSURE IN THE STANDARD HAN BEING, POWER IS CUT OFF AND THE BEING ARE APPLIED.	1	ADDED		

2.0 SYNOPSIS

ITEMS RELEASED									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE			CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RECOMMENDATIONS	VERIFICATION	
	CONTINUING	COMPLIANCE	TECH. REF.		PARTICIPATION			HOW	RESULTS
2.0 HUMAN FACTORS 2.2 ACCESS SERVICES	PAL 3.3.3.1 3.1			REMOVAL OF ANY REPLACEMENTS WITH SMALL MODULES OPERATING ON REMOVAL OF A KIDNEY NUMBER OF COVERING, OR PANELS (PROBABLY ONE).			THE TWO TRUCK BATTERIES ARE ASSEMBLED WITH THE BATTERY CASE COVER WHICH IS FASTENED BY FOUR SCREWS IS REMOVED. AN ELECTRICAL OUTLET HAS BEEN PROVIDED TO FACILITATE THE ATTACHMENT OF THE BATTERY CHARGER LEADS AND TO ELIMINATE THE NEED FOR REMOVING THE BATTERY COVER FOR THIS PURPOSE.	1	ASSESSMENT IS IN PROGRESS 5
2.4 BATTERIES, REMOVED - REPLACE	PAL 3.3.3.1 AND 300C PAL 3.3.5 AND 300-1 PAL 7000			SPECIAL HANDLING INSTRUCTIONS MUST BE PROVIDED FOR BATTERIES EXCEEDING 140 LBS. WHICH MUST BE LIFTED MORE THAN ONE FOOT. THE BATTERY MUST BE LIFTED APPROX. 3 FEET AND NOTION 140 LBS.			IT IS RECOMMENDED THAT SOME SPECIALIZED LIFTING, A BLEND OR AN ADAPTED LIFTING BE PROVIDED FOR LIFTING THE BATTERY WHICH WOULD BE CONSIDERABLE FOR THE KITE THE MAINTENANCE BUILT OR OTHER LIFTING DEVICE.	1	NOT ADVISED 5
2.6 VEHICLE MAINTENANCE	AND 300C PAL 3.3.1 3.3.5.1			THE TWO TRUCK BATTERIES MUST BE FUNCTIONING WITHIN A KIDNEY THE INTERNAL AND WITH A KIDNEY NUMBER OF OPERATOR REMOVAL.	20-000-100 1/14/79.		REPAIR FACTORY REVIEW OF THE BATTERY OPERATING INSTRUCTIONS (FOR THE TWO TRUCKS) REVEALED THAT THE TWO TRUCK OPERATIONS WERE EXACTLY THE SAME AND THAT REPAIRS RECOMMENDED BY THE OPERATOR WERE INADEQUATE. (SEE 3.1 OF THIS CHART). THE FOLLOWING RECOMMENDATIONS WERE MADE:	1 1 1	SEE/NO NO. 177 ALIVE WITH REPAIRS 177

2.0 SYNOPSIS

ITEM: TWO TRUCK						
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		REMARKS
	COMPLIANCE	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	
2.4 VEHICLE REPRESENTATIVITY (ONE'S)					1. A SENSITIVE CRITERIA PLAN SHOULD BE ADAPTED WHEN WELL BE COMPATIBLE WITH THE CLOSE TOLERANCES OF THE TRUCKS AND VEHICLES IN THE TRUCKS. WHEN IS ELIMINATED AND TRUCKS THE LEFT TO A HIGHWAY. 2. TRAFFIC WARNING SIGNALS SHOULD BE USED TO HELP THE MOVEMENT OF TRUCKS AND PERSONNEL IN THE TRUCKS SAFE AND CORDON. 3. A COMPLETE SENSITIVE SHOULD BE MADE OF TRUCKS TRUCKS PROBLEMS. 4. TRAFFIC WARNING SIGNALS SHOULD BE USED TO HELP THE MOVEMENT OF TRUCKS AND PERSONNEL IN THE TRUCKS SAFE AND CORDON. 5. A COMPLETE SENSITIVE SHOULD BE MADE OF TRUCKS TRUCKS PROBLEMS.	
3.0 SAFETY						
3.5 SAFETY DISTANCE (OTHER)	PAL 7.2	AS - 1000 PAL 3.2.1	TO PREVENT MAINTAINING OPERATION OF THE TWO TRUCKS, A KEY LOCKED DISTANCE SHOULD BE ENFORCED.		THE TWO TRUCKS CRITERIA INCLUDE A KEY LOCKED DISTANCE CRITERIA.	5
	PAL 7.11	AS - 1000 PAL 6.1.1	TO PREVENT COLLISIONS CAUSED BY A TRUCK MOVING FOR A COLLISION, A FIVE EXTENSION SHOULD BE APPLIED TO THE TWO TRUCKS.		A FIVE EXTENSION IS PROVIDED OF THE TWO TRUCKS.	5

2.0 SYNOPSIS

ITEM: TWO THREE						
HUMAN FACTORS	DOCUMENTATION COMPLIANCE CONTRACTUAL AFM 1.1.10.1	TECH REF	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RESULTS
				PARTICIPATION	RECOMMENDATIONS	
3.5 SAFETY SERVICES (OTHER) (CONT'D)		AS - 3000 B PAR. 3.1.10.1	THE TWO THREE OPERATES IN OR NEAR HAZARDOUS AREAS WHERE SPARKING IS NOT PROHIBITED. TO REDUCE THE POSSIBILITY OF BYPASSING OF SAFETY CLARKE, THE TWO THREE SHOULD HAVE CONNECTIVE VEHICLE.		THE TWO THREE IS EQUIPPED WITH CONNECTIVE TIES OF ITS VEHICLE.	CRITERIA SATISFIED
3.6 MAINTENANCE SERVICES	PAR. 7.3	AS - 3000 C PAR. 3.1	A MAINTENANCE SERVICE SHOULD BE PROVIDED TO MAINTAIN FUNCTIONING OF INTERFERENCE OR EXCESSIVE SIGNALS.		THE TWO THREE IS EQUIPPED WITH A BAND OPERATOR AT THE MAINT.	CRITERIA SATISFIED

2.0 SYNOPSIS

3.0 DISCUSSION

The tunnel cross-section and the anthropometric dimensions of operating personnel cannot be compromised. A Tug Truck which allows the driver to sit down (MF-T-1041) would reduce the necessary overhead clearance from 83" to 71.6". Additional benefits resulting from the paramount objective of sufficient head clearance would be greater driver comfort (seated operation) increased maneuvering efficiency (no ducking, bending distractions) and increased speed (no fear of physical injury).

An integrated traffic study (all contractors' traffic problems) should be conducted to determine the optimum method of transportation with the minimum time consumption to complete the tasks. The existing wooden guide rails limit operator efficiency and restrict the number of units in tow to one. Backing and turning within tunnel junctions using the present system is a time consuming operation involving several workers. Guidance systems have been proposed which would be compatible with present vehicles and would increase the efficiency of vehicular transportation in the tunnels.

4.0 REFERENCES

1. AFEM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ASA Z53.1-1953, Safety Color Code for Marking Physical Hazards and Identification of Certain Equipment.
3. AMS 1001D-Detail Model Spec. for WS 107A-2 Launcher System.
4. AMF Design Specification - ADS 1003C - Personnel Safety for WS 107A-2 Launcher System.
5. ASA B56-1 - Safety Code for Industrial Power Trucks.
6. AHFP-V-5226 - Human Factors Test Procedure for Evaluation of the Tug Truck - WS 107A-2 Launcher System.
7. AMF Report, ER-TPS-190, Tunnel Guidance Requirements OSTF-TB-OB, 3/16/59.
8. AMF Report, ER-V-92, Operational Test of the Tug Truck with Mobile Maintenance GSE, 3/13/61.
9. AMF Report, ER-TPS-121, Tug Truck Requirements, 10/6/58.
10. AMF Report, ER-TPS-119, Human Engineering Study of Clearance in Tunnel for Personnel, 9/30/58.
11. AMF Report, FTR-V-408, Tug Truck Design Changes, 10/17/61.
12. AMF Drawing No. HF-T-1041 - Tug Truck, Seated Operator versus OB Tunnels.

13. AMF Drawing No. HF-T-1158 - Study, Rail Guidance System OB
Tunnel.

Chapter 17

Human Factors Review and Evaluation
of the
Power Pack

NOISE PROTECTION



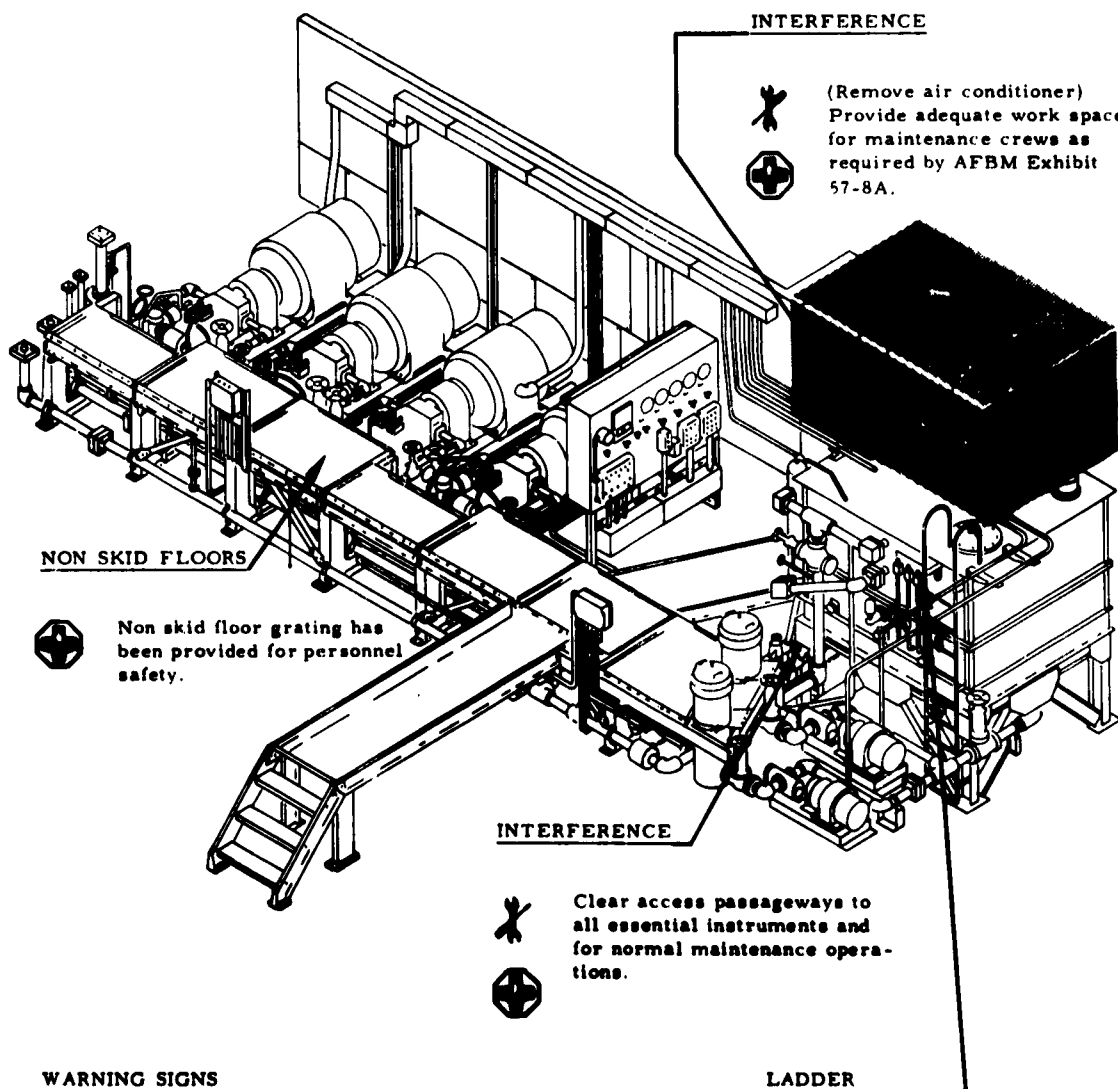
Provide noise protection to reduce human error in telephone conversations, to reduce possibilities of injury to personnel, and to increase efficiency of human performance.



LABELS



Permanent labels should be provided for each control and display.



WARNING SIGNS



Provide hazard warning signs to comply with A. S. A. Z 35.1 - R 1945.



FIGURE 17-1
HUMAN FACTORS INPUTS
POWER PACK
ROOM

Arrange controls and displays to comply with AFBM Exhibit 57-8A.

Arrange controls and displays to comply with AFBM Exhibit 57-8A.

 A warning horn indicates trouble in essential functions of the hydraulic supply system.

 A warning horn indicates trouble in essential functions of the hydraulic supply system.

 Controls and displays associated with warning devices should be connected to circuitry which is fail safe (self checking against human error).

 Controls and displays associated with warning devices should be connected to circuitry which is fail safe (self checking against human error).

 Locate pressure gauges so that normal readings are at 9 o'clock position.

 **Locate pressure gauges so that normal readings are at 9 o'clock position.**

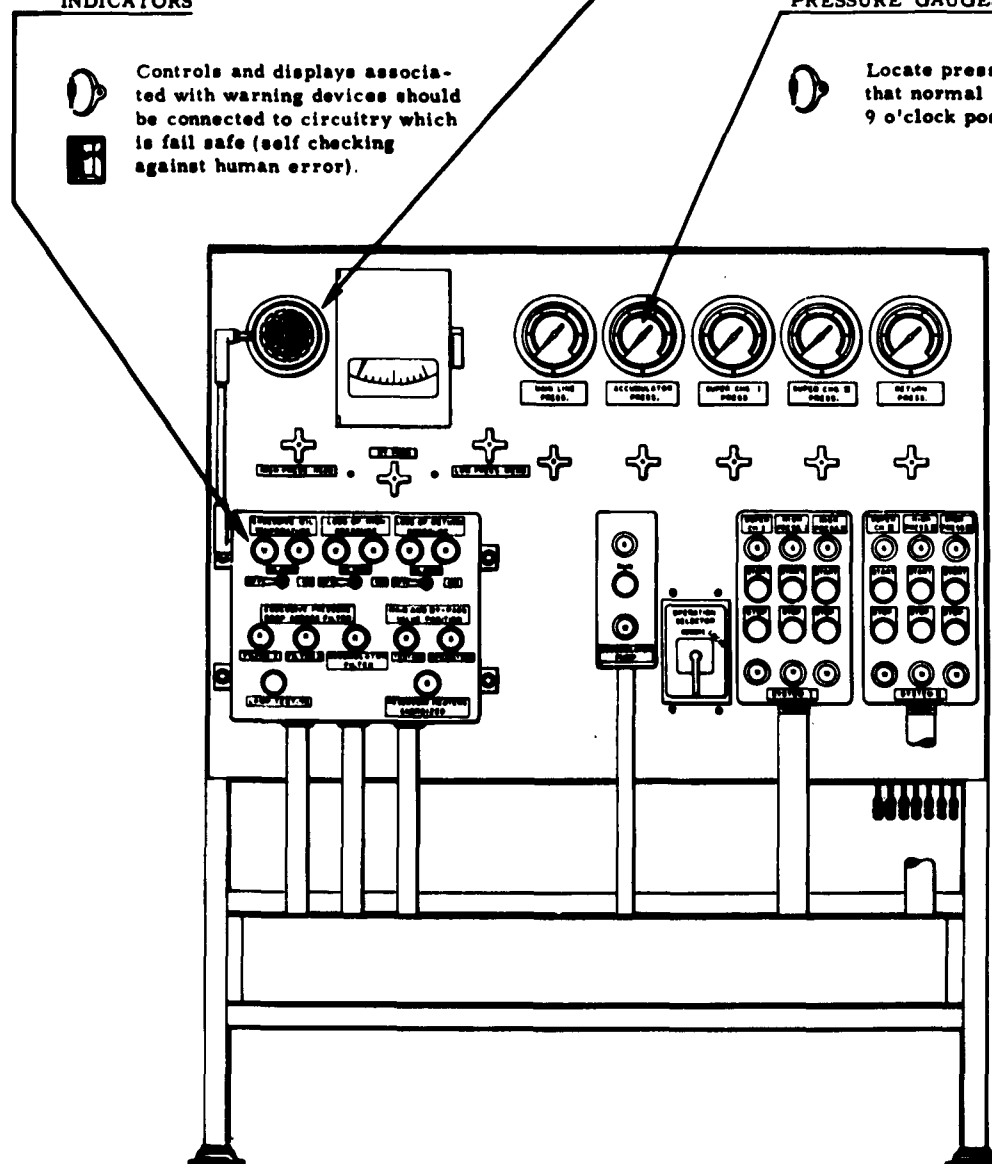


FIGURE 17-2
HUMAN FACTORS INPUTS
CYCLING CONTROL
STATION

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: POWER PACK		Human Factor Effort Required										PHASE IN STAGE	HUMAN FACTORS OBJECTIVE	APPLICABLE ON MODEL
		Concept	Review	Analysis	Field Input	Specification Compliance	Safety	Operational Status	Maintenance Recommendation	Product Improvement	OSTF	TF	OS	SYMBOL
1.0 HUMAN ENGINEERING DESIGN FACTORS														
1.1	Anthropometric Computability	*	*					*		*	*	*	*	
1.2	Controls and Displays	*	*					*		*	*	*	*	
1.3	Fail-Safe Design													
1.4	Malfunction Detection													
2.0 MAINTENANCE FACTORS														
2.1	Access, Visual													
2.2	Access, Servicing	*	*					*		*	*	*	*	
2.3	Remove and Replace	*	*					*		*	*	*	*	
2.4	Handling, Physical Limitations													
2.5	Handling, Transportation													
2.6	Vehicle Maneuverability													
3.0 SAFETY FACTORS														
3.1	Chemical Decontamination													
3.2	Escape Provisions													
3.3	Protection from Entanglement													
3.4	Protection from Falling	*	*			*				*	*	*	*	
3.5	Safety Devices (other)		*			*				*	*	*	*	
3.6	Warning Devices	*	*			*				*	*	*	*	
4.0 PHYSIOLOGICAL FACTORS														
4.1	Biological Damage							*						
4.2	Vertigo													
4.3	Vibration Effects													
5.0 PSYCHOLOGICAL FACTORS														
5.1	Fear of Heights													
5.2	Fear of Being Crushed													
5.3	Fear of Falling													
5.4	Fear of Isolation													
5.5	Feeling of Insecurity													
6.0 ENVIRONMENTAL FACTORS														
6.1	Acoustic Energy (noise)	*	*					*		*	*	*	*	
6.2	Humidity & Temperature													
6.3	Illumination													
7.0 HUMAN USE FACTORS														
7.1	Procedure													
7.2	Time Study													
7.3	Training/Selection													

FIGURE 17-3

1.0 DESCRIPTION OF THE POWER PACK ROOM

1.1 The power pack supplies the hydraulic power used to move the launcher platform, silo doors, work platforms, and other components in the Titan Launcher System. The equipment in the Power Pack Room includes the following:

- a. A reservoir of sufficient capacity to supply fluid to all of the hydraulic cylinders and motors throughout the system which must be actuated at a given time.
- b. Pumping systems which are connected to the reservoir by a common feed line through a manual shut off valve.
- c. Two accumulators ("Greer" Model 30A-10A 3/4) which store hydraulic energy supplied on demand by a fixed displacement pump. An Accumulator Circuit Mounting Panel connects the accumulators to the pump which automatically maintains a standby pressure of 500 psi throughout the system.
- d. A Cycling Control Station used as a local control during cycling tests.
- e. Grating and pipe supports which are used as catwalks and a means of holding the pipe lines.
- f. Two Pressure Switch Boxes which electrically connect pressure points within the Power Pack to the Annunciator Panel indicators.

1.2 APPLICABLE HUMAN FACTORS CONSIDERATIONS FOR THE POWER PACK ROOM

Equipment in the Power Pack Room must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls and displays should be designed and located so as to reduce the probability of operator error. Warning labels and alerting devices

should be provided for potentially hazardous conditions. Access should be provided for all equipment which requires maintenance. Steps should be taken to reduce the noise level if it interferes with operator performance or is physically detrimental to personnel. Factors contributing to the successful use of the Power Pack have been itemized on the summary checklist (Fig. 17-3) and the progress of the Power Pack design has been tabulated in detail in the following synopsis.

ITEM: JUNE 1971 308									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS	96	DATE
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS				
1.0 HUMAN PERFORMANCE SECTION FACTORS									
1.2 CONTROLS AND DISPLAYS	PAR. 2.2.1		LABELS SHOULD BE LOCATED ADJACENT TO CONTROLS AND DISPLAYS TO BE IDENTIFIED AND SHOULD IDENTIFY APPROPRIATE TO FUNCTION.	REMARKS SECTION AND RECOMMENDATIONS REF: 2.2.1-206	LABELS SHOULD BE PROVIDED FOR MANUAL STARTUP KEYS ON THE ACCUMULATOR CIRCUIT PANEL AND FOR CONTROLS AND DISPLAYS ON THE CYCLING CONTROL SECTION.		I	NOT ADOPTED	
	PAR. 2.2.2.A		LABELS SHOULD BE REPRODUCED OR REPRODUCED.	SAME AS ABOVE	LABELS FOR ALL PANELS IN THE POWER PACK MUST BE REPRODUCED IN REPRODUCED OR REPRODUCED.		I	NOT ADOPTED	S
	PAR. 2.3.1.3.2		REPRODUCED LINES SHOULD BE USED TO REPRODUCE THE COMPLEXITY OF A COMPLEX IN ADDITION TO LINES WHICH SHOW THE SEQUENCE OF OPERATIONS.	SAME AS ABOVE	ONE AND LIGHT INDICATION ON THE ACCUMULATOR PANEL WAS REPRODUCED FOR EACH OF THE FOLLOWING THERMAL CIRCUITS: EXCESSIVE OIL TEMPERATURE; LOSS OF OIL PRESSURE; LOSS OF OIL FLOW; LOW OIL LEVEL; EXCESSIVE PRESSURE DROP ACROSS FILTER I, FILTER II, ACCUMULATOR FILTER.		I	NOT ADOPTED	S
	PAR. 2.1.1.A AND 3.1.1.A		PROCESSES ARE DESCRIBED FOR THE LOCATION OF DISPLAYS AND CONTROLS TO MINIMIZE OPERATING TIME AND THE POSSIBILITY OF OPERATING ERROR.	SAME AS ABOVE.	RECOMMENDATIONS WERE MADE FOR THE ARRANGEMENT OF CONTROLS AND DISPLAYS ON THE CYCLING CONTROL SECTION AND THE ACCUMULATOR CONTROL PANEL ASSEMBLY.		I	NOT ADOPTED	S

2.0 SYNOPSIS

[illegible]

ITEM: 2000-2000-2000		DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	ITEM NUMBER
HUMAN FACTORS	CONSTRUCTION APPROVAL	TECH REF.	PARTICIPATION		RECOMMENDATIONS	ANALYSIS	TEST			
2.2 ACCESS, SERVICING (CONTINUED)		A.5.1. ALL. 3-1996		REQUIREMENTS FOR FIXED LADDERS ARE SPECIFIED.	DESIGNED SYSTEM AND INSPECTION REPORT 20-000-2000.	THE FOLLOWING RECOMMENDATIONS WERE MADE: A. MINIMUM CLEARANCE BETWEEN CABLES SHOULD BE 14 INCH. B. EXCESSIVE AND REBARRED FOR LADDERS SHOULD BE .75 INCHES. C. MINIMUM EXCESSIVE BETWEEN TOP AND-BAIL EXTENSIONS SHOULD BE 2.5 INCHES.	X	X	NOT ADAPTED	12
3.0 SAFETY FACTORS 3.1 PROTECTION FROM FALLING	PAL. 7.22			RED PROOF FLOORING SHOULD BE PROVIDED ON STAIRS AND DEEP STAIRS.	SAME AS ABOVE	RED-PROOF FLOORING SURFACES SHOULD BE PROVIDED ON ALL CAT WALKS.	X	X	ADAPTED	13
3.6 HAZARDOUS SUBSTANCES	PAL. 7.1 AND 7.20	ANSI Z 35.1 8-1999		PLACARDS SHOULD BE PLACED TO WARN OF POTENTIALLY HAZARDOUS CONDITIONS.	SAME AS ABOVE	A CHARTER SIGN SHOULD BE PLACED 66 INCHES FROM THE FLOOR ON THE OUTER LINE OF THE LADDER. MARKED ON THE RESISTANT TAIL. THE SIGN SHOULD READ: "CAUTION: HAZARDOUS SUBSTANCE ON TOP & FLOOR". A LABEL SHOULD APPEAR ON EACH APPROXIMATE TO ONLY THE APPROXIMATE TO (1) RELEASE FLUID PRESSURE BEFORE DISCONNECTING THE PRESSURE LINE AND (2) RELEASE GAS AND FLUID PRESSURE BEFORE DISCONNECTING THE APPROXIMATE.	X	X	NOT ADAPTED	5

2.0 SYNOPSIS

ITEM: 17-9-92-1000						21700 21700	
HUMAN FACTORS	DOCUMENTARY COMPLIANCE CONTINGENCY AFTER 5-10 TODA REF	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS
			PARTICIPATION	RECOMMENDATIONS	VALUATION	TEST	
3.6 WARNING DEVICES (CONTINUED)	PAL 7.3	A HAZARD ALERTING DEVICE SHOULD BE PROVIDED TO WARN PERSONNEL OF IMPENDING OR EXISTING HAZARDS.	WARNING DEVICES AND RECOMMENDATIONS REF: 10-100-100.	AN ADVERSE NOISE CIRCUMSTANCE SHOULD BE PROVIDED WHICH WOULD BE SUBJECT TO IMMEDIATE TREATMENT IN THE FOLLOWING CIRCUMSTANCES: A. EXCESSIVE OIL TEMPERATURE, B. LOSS OF OIL PRESSURE, C. LOSS OF BATTERY POWER, AND D. LOW OIL LEVEL.	1	1	ADDED
6.0 ENVIRONMENTAL FACTORS 6.1 ACOUSTIC ENVIRONMENT (NOISE)	PAL 5.1.1.2 AND 5.1.1.4	NOISE IS REDUCED BY CONSTRUCTING BARRIERS BETWEEN THE NOISE AREA AND THE SOURCE OF NOISE AND BY INCLUDING NOISE CONTROL DEVICES.	SAME AS ABOVE ALSO FIELD TESTS OFFICIAL NOISE READINGS, CONTENTS OF 100-1-100 (POWER PAC TEST PLAN) AND OBSERVATIONS MADE BY FACTORS DURING THE VISITING THE FIELD (77-1) ALL INDICATE THAT NOISE LEVELS WOULD BE POWER PAC NOISE POWER VIOLATE 100-1-100 AND NOISE APPROXIMATIONS REFERENCED THEREIN. OFFICIAL TEST DATA WHICH IS THE CONTENT OF 100-1-100 (HYDRAULIC NOISE NOISE-LEVEL TEST) HAS NOT YET BEEN COMPLETED.	THE CYCLING CONTROL DEVICES INCLUDING THE TELEPHONE SHOULD BE REMOVED WITHIN A SOUND BARRIER TO INCREASE THE EFFECTS OF NOISE.	1	1	NO COPY

3.0 DISCUSSION FUTURE DEVELOPMENT PROGRAMS

3.1 Problem areas which should be considered early in the concept stage of future hydraulic power pack designs are:

- a. Access to all manual valves should be provided for visual inspection, adjustment, and servicing. Visual access must also be provided to all gauges, thermometers, flow meters, etc. so they can be read easily and accurately.
- b. Personnel must not be exposed to noise levels which can permanently cause hearing loss or can temporarily reduce effective use of voice communication, telephone conversation or warning devices.

3.2 The following concept is recommended to improve future power packs with respect to human factors:

- a. Divide the power pack room into two sections separated by a sound proof wall.
- b. Locate all pumps, filters, valves, piping and the reservoir along the back side of the wall so that valve handles, gauges, level indicators, thermometers, etc. appear on the front side in proper juxtaposition along a line schematic of the system.
- c. Color code the painted lines to represent various required pressures.
- d. Provide a vibration insulated catwalk along the entire length of the control surface with one large insulated door for access to the machinery side.

Operators will be able to instruct new personnel using the flow diagram as a training aid and the system will be easy to trace for malfunctions. Noise will not interfere with conversations

and warning devices. Personnel will not be subjected to injurious noise levels which can temporarily decrease efficiency and permanently impair hearing.

4.0 REFERENCES

1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. AFBMD, Deviation from WDT Policy Memorandum #7 Color Schemes for Console Panels, etc., 2/11/59.
3. AFBMD, Colors for Ground Equipment, 12/2/59.
4. ASA, A14.3-1956, Fixed Ladders.
5. ASA, Z35.1 - R 1945, Specifications for Industrial Accident Prevention Signs.
6. Ernest J. McCormick, Human Engineering, New York, McGraw-Hill Book Company, Inc., 1958, Page 375.
7. AMF Report, ER-TPS-206, Power Pack - Human Factors Review - Mandatory & Recommended Changes, 4/13/59.
8. AMF Report, ER-TPS-242, Air Conditioner vs Hydraulic Reservoir (T-2), 11/4/59.

Chapter 18

Human Factors Review and Evaluation
of the
Launcher Platform

FAIL SAFE DESIGN

- The "A" frame retraction jack cover can be screwed down only if the jacks have been removed; this insures that the jacks have been removed before the Launcher Platform is operated.

SAFETY



Walking surfaces on the service platform are of a non-skid material,

Removable handrails have been provided on the service platforms.

A safety net has been permanently installed to prevent injury to personnel falling into the Flame Deflector.

ACCESS



Access between the "A" frame and the Umbilical Tower should be adequate for the 95th percentile man.

Access to the Flame Deflector and launcher to crib seal deck have been provided.

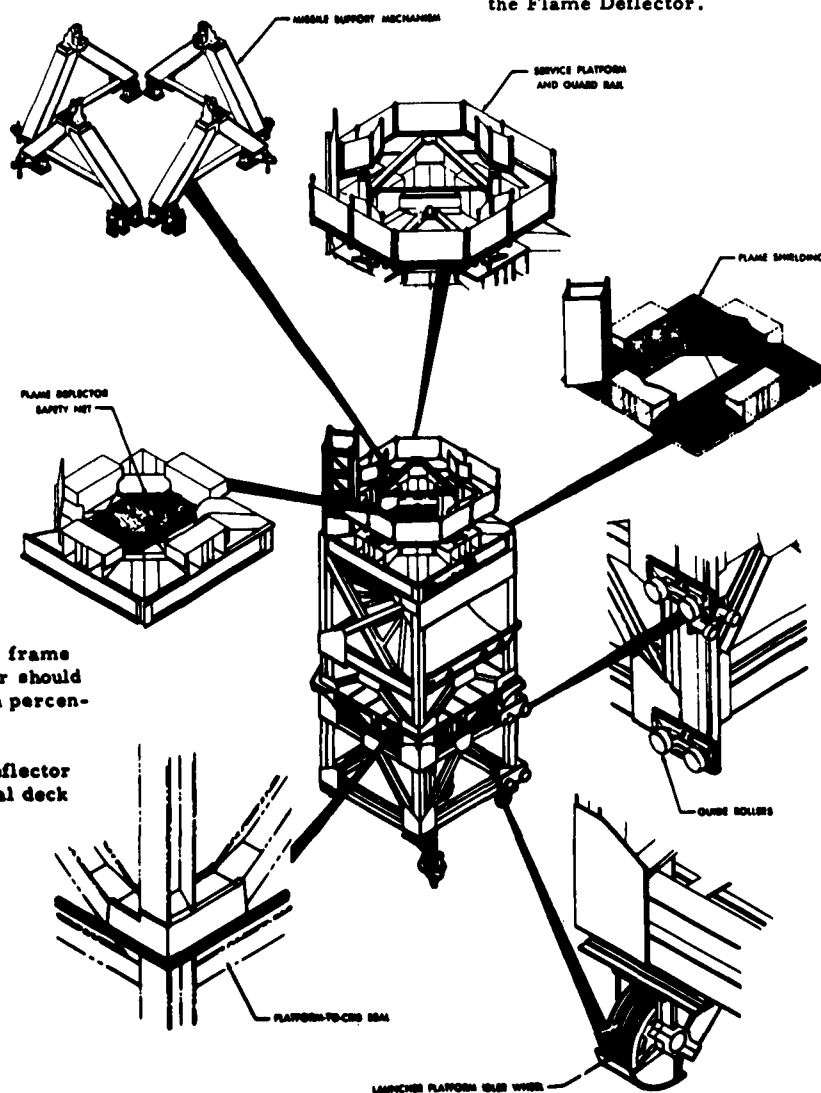


FIGURE 18-1
HUMAN FACTORS INPUTS
LAUNCHER PLATFORM

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: LAUNCHER PLATFORM (EXCLUDING ACCESSORY EQUIPMENT)									
	Human Factor Effort Required	PHASE IN STAGE			HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation	Product Improvement OSTF	TF	OB
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability_____	*	*			*	*	*	*	
1.2 Controls and Displays_____		*			*	*	*	*	
1.3 Fail-Safe Design_____	*	*			*	*	*	*	
1.4 Malfunction Detection_____									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual_____									
2.2 Access, Servicing_____	*	*			*	*	*	*	
2.3 Remove and Replace_____	*	*			*	*	*	*	
2.4 Handling, Physical Limitations_____									
2.5 Handling, Transportation_____									
2.6 Vehicle Maneuverability_____									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination_____									
3.2 Escape Provisions_____									
3.3 Protection from Entanglement_____									
3.4 Protection from Falling_____	*	*			*	*	*	*	
3.5 Safety Devices (other)_____									
3.6 Warning Devices_____									
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage_____									
4.2 Vertigo_____									
4.3 Vibration Effects_____									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights_____									
5.2 Fear of Being Crushed_____									
5.3 Fear of Falling_____	*	*			*	*	*	*	
5.4 Fear of Isolation_____									
5.5 Feeling of Insecurity_____									
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)_____									
6.2 Humidity & Temperature_____									
6.3 Illumination_____									
7.0 HUMAN USE FACTORS									
7.1 Procedure_____									
7.2 Time Study_____									
7.3 Training/Selection_____									

FIGURE 18-2

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: LAUNCHER PLATFORM ACCESSORY EQUIPMENT										
	Human Factor Effort Required				PHASE IN STAGE	HUMAN FACTORS OBJECTIVE				APPLICABLE ON MODEL
	Concept Review	Analysis	Field Input	Specification Compliance		Safety	Operational Status	Maintenance Recommendation	Product Improvement	
										OSTF TF OB SYMBOL
1.0 HUMAN ENGINEERING DESIGN FACTORS										
1.1 Anthropometric Compatibility	*	*				*		*	*	
1.2 Controls and Displays										
1.3 Fail-Safe Design	*	*				*		*	*	
1.4 Malfunction Detection										
2.0 MAINTENANCE FACTORS										
2.1 Access, Visual										
2.2 Access, Servicing										
2.3 Remove and Replace	*	*				*		*	*	
2.4 Handling, Physical Limitations	*	*				*		*	*	
2.5 Handling, Transportation										
2.6 Vehicle Maneuverability										
3.0 SAFETY FACTORS										
3.1 Chemical Decontamination										
3.2 Escape Provisions										
3.3 Protection from Entanglement										
3.4 Protection from Falling	*	*				*		*	*	
3.5 Safety Devices (other)										
3.6 Warning Devices										
4.0 PHYSIOLOGICAL FACTORS										
4.1 Biological Damage										
4.2 Vertigo										
4.3 Vibration Effects										
5.0 PSYCHOLOGICAL FACTORS										
5.1 Fear of Heights										
5.2 Fear of Being Crushed										
5.3 Fear of Falling										
5.4 Fear of Isolation										
5.5 Feeling of Insecurity										
6.0 ENVIRONMENTAL FACTORS										
6.1 Acoustic Energy (noise)										
6.2 Humidity & Temperature										
6.3 Illumination	*	*				*		*	*	
7.0 HUMAN USE FACTORS										
7.1 Procedure										
7.2 Time Study										
7.3 Training/Selection										

FIGURE 18-3

1.0 DESCRIPTION

1.1 In this chapter the human factors will be considered which are pertinent to the design and installation of the Launcher Platform and its accessory equipment.

1.1.1 Launcher Platform (Excluding Accessory Equipment)

1.1.2 Description of Launcher Platform (Excluding Accessory Equipment)

The Launcher Platform is the missile supporting structure in all cycles.

It is mounted within guide rails on rollers and is the elevating platform for raising and lowering the missile between the storage position and the launching position.

The Launcher Platform provides a common framework for attachment and support of the following major components:

1. Service Platform
2. Missile Support System
3. Flame Shielding
4. Missile Support System Pedestal
5. Flame Deflector Cooling Spray System
6. Flame Deflector
Flame Deflector Extension
8. Platform-to-Crib Lock Brackets
9. Guide Roller Assembly
10. Idler Sheaves
11. Water Connection System
12. Platform-to-Crib Seal
13. Launcher Platform Structure
14. Engine Compartment Water Spray System
15. Umbilical Tower Base

1.1.3 Applicable Human Factors Considerations for Launcher Platform (Excluding Accessory Equipment)

The Launcher Platform must be designed for operation by Air Force personnel between the 5th and 95th percentile. Adequate work space must be provided for personnel who service the unit. All components must be accessible for maintenance. Fail safe design features should be provided whenever serious damage to the Launcher Platform equipment is possible. Consideration should be given to skid-proof flooring.

1.2 Launcher Platform Accessory Equipment

1.2.1 Description of Launcher Platform Accessory Equipment

The Launcher Platform accessory equipment includes the Engine Maintenance Stands and the Igniter Maintenance Stands. These stands are used to perform maintenance on the missile and are removable. The stands are of an aluminum tubular truss construction.

1.2.2 Applicable Human Factors Considerations for Launcher Platform Accessory Equipment

The accessory equipment must be designed for operation by Air Force personnel between the 5th and 95th percentile. The stands must be designed so that they can be put in place and removed safely and efficiently. They should provide proper access to the missile components. The necessary guard rails should be provided to protect the operators from falling.

ITEM: LAUNCH PLATFORM (EXCLUDED AIRCRAFT BRIDGE)						
HUMAN FACTORS	DOCUMENTARY COMPLIANCE CONSTRUCTION ATM 51-1A	TECH REF	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RESULTS
				PARTICANTION	RECOMMENDATIONS	
1.0 BRIDGE INSTRUMENTATION DESIGN FACTORS						
1.1 INSTRUMENTED COMPREHENSIBILITY	4.1.1	WASC 78 53-101	THE INSTRUMENT DESIGN FOR PARADOX MUST REQUIRE 13 INCHES.	THE SPACE BETWEEN THE "A" FRAME AND THE UNILICAL TOWER AT VALENT RETORT ON THE SERVICE PLATFORM IS 11.9 INCHES.	THIS DEFERENCE SHOULD BE INCREASED TO 13 INCHES SO THAT THE OPERATOR WILL NOT BE REQUIRED TO WALK AROUND THE MISSILE TO REACH THE OTHER SIDE OF THE UNILICAL TOWER.	THE OVERALL SPACE LIMITATIONS PRESENTED AS INCREASE IN THIS INSTRUMENT.
1.2 FAIL SAFE DESIGN	1.1		ALL REMEDIABLE DEFECT SHOULD BE REQUIRED TO AVOID A FAIL-SAFE DESIGN IN THOSE AREAS WHERE WHICH RELIABILITY CANNOT BE EXPECTED AND THE CONSEQUENCES OF FAILURE MAY RESULT IN THE INTERRUPTION OF EQUIPMENT OR DAMAGE TO PERSONNEL.	DAMAGE CAN RESULT IF AN ATTEMPT IS MADE TO OPERATE THE LAUNCHER PLATFORM WITHOUT FIRST MOVING THE JACKS FOR THE MISSILE SUPPORT VERTICALLY.	IT WAS DETERMINED THAT EITHER (A) A REMEDIABLE PLAN BE PROVIDED IN THE OTHER FOR VISUAL ACCESS, (B) THE COVER BE INCREASED SO THAT IT CANNOT BE CLOSED UNTIL THE JACKS ARE REMOVED, OR (C) THE JACKS BE LOCKED UNDERNEATH THE PLANE SHIELD.	PERSONNEL WAS CHARGED TO INCREASE PROBLEM.
2.0 MAINTENANCE FACTORS						
2.2 ACCESS, SERVICING	4.1.2.1.1		IT SHOULD BE POSSIBLE TO USE EMPLOYED TOOLS WITHOUT DIFFICULTY OR HAZARD.	TYPE CHANGE REQUEST DATED 5/24/60.	THE AIR LINE TIP IN THE SILD SHOULD BE MADE AVAILABLE AT EACH PLATFORM LEVEL FOR USE IN CLEANING OR USING AIR TOOLS.	PERSON CHARGED TO INCREASING TOOL RELIABILITY THIS REQUEST.
	4.2.1		UTILIZATION IS ONE OF THE GENERAL PRINCIPLES OF EQUIPMENT DESIGN FOR MAINTAINABILITY. UTILIZATION REQUIRES THAT EQUIPMENT BE DESIGNED TO PROVIDE FOR MAINT AND LAST SERVICE OF WHICH BE A SINGLE OPERATOR, IF POSSIBLE.	PARAGRAPH 3.1 OF DESIGN SPECIFICATION AND-2018, DATED JUNE 26, 1959	THE SERVICE PLATFORM SHOULD PROVIDE ACCESS FOR SERVICING THE STAGE 1 MISSILES AND MISSILE SUPPORT ARMS AT THE ELASTICITY 30" 5.25" THROUGH 11A", THE MAIN FUEL CONNECTIONS, AND LIQUID COOLING MECHANISMS AND CONNECTIONS.	ACCESS IS STILL A PROBLEM

2.0 SYNOPSIS

ITEM: LATERAL PLATFORM (INCLUDING ACCESSORY EQUIPMENT)									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS	15	20
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS				
2.3 XEROX - REPLACEMENT	6.2.1		EQUIPMENT SHOULD BE DESIGNED TO PROVIDE FOR EASY AND FAST REMOVAL AND REPLACEMENT OF UNITS BY A SINGLE OPERATOR.	REF DOCUMENT IS 7.2.38, V.1/No.	RECOMMENDATIONS WERE MADE FOR THE IMPROVEMENT OF THE REMOVAL AND REPLACEMENT OF UNITS. THE RECOMMENDATIONS ARE DESCRIBED IN DETAIL IN THE REF DOCUMENT.	I	NO SPECIAL PROBLEMS IN IMPLEMENTATION OF COLLECTIVE.		
3.0 SAFETY FACTORS 3.4 PROTECTION FROM FALLING	7.22	PMB. 5.3.3.6 OF CHAPTER 5 IN VOLUME 1 OF ARMY MANUAL 80-4.	PROVIDE WITH PROOF PLANNING.	PARTICULAR 3.5 OF SECTION SPECIFICATION AND-2000, DATED JUNE 26, 1999.	THE DESIGN OF THE SAFETY PLATFORM SHOULD PROVIDE FOR REMOVAL AND REPLACEMENT OF UNITS BY A SINGLE OPERATOR. THE APPLICATION OF A CORRECTIVE REMOVAL AND REPLACEMENT.	I	RECOMMENDATION SAFETY. REMOVAL AND REPLACEMENT.		

ITEM: LANCELOT PLATFORM ACCESSORY EQUIPMENT									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE CONTRACTUAL FORM 2-1A	TECH REF	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS		
				PARTICIPATION	RECOMMENDATIONS	ANALYSIS/TEST			
1.0 HUMAN ENGINEERING DESIGN FACTORS 1.1 ANTHROPOMETRIC COMPATIBILITY	4.1.1		THE KNEEBOARD OVERLAP DESIGN FOR STANDING POSITION IS 75 INCHES.	SERVICE PLATFORM NUMBER 6 IS 4' 1.6" ABOVE THE MAINTENANCE STAND AND THE MISSILE KIVE IS 5' ABOVE THE MAINTENANCE STAND. AS A RESULT THE REACHING IS IMPOSSIBLE AT THE POINT WHERE THE SERVICE PLATFORM AND KIVE ARE DIRECTLY OVER THE STAND.	KIVE THE EQUIPMENT SHOULD BE DESIGNED TO PERMIT NO RE REACHING OR REACHING SHOULD BE PROVIDED.	I	YES REACHING CALCULATED BE INCREASED DUE TO THE ADVANCED DESIGN OF THE LANCELOT PLATFORM.	20	
1.2 FAIL SAFE DESIGN	1.4		ALL REASONABLE EFFORTS SHOULD BE EXPENDED TO ENSURE THE ACTIVE- SAFE OF A FAIL-SAFE DESIGN IS TWO TIMES AS HIGH AS THE RELIABILITY OF THE EQUIPMENT AND THE CONSEQUENCES OF FAILURE COULD BE LIFE OR DEATH TO PERSONNEL EQUIPMENT OR DAMAGE TO PROPERTY.	THE SUPPORT FOR THE EQUIPMENT MAINTENANCE STAND SHOULD BE DESIGNED UNDER ALL OPERATING CONDITIONS.	A FAIL-SAFE CLIPPING DEVICE SHOULD BE PROVIDED.	I	YES CLIPPING DEVICE PROVIDED IS A FAIL-SAFE DEVICE.	15	
2.0 MAINTENANCE FACTORS 2.1 ACCESS, MOVING AND REPLACE	4.2.1		ALL EQUIPMENT SHOULD BE DESIGNED SO THAT INSTALLATION AND REMOVAL CAN BE ACCOMPLISHED EASILY AND RAPIDLY.	750 ADJACENT MAINTENANCE STANDS MUST BE INSTALLED TO ENSURE TO PROVIDE SUFFICIENT STRUCTURAL SUPPORT. AS A RESULT THE ACCESS ROOM IS SEVERELY LIMITED.	RECOMMENDATIONS WERE SUBMITTED TO ENSURE THE AVAILABLE AREA.	I	NO ADDITIONAL ACCESS ROOM COULD BE PROVIDED AT TP-1.	15	

2.1 SYNOPSIS

ITEM: LANDING PLATFORM ACCESSORY EQUIPMENT									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	PRIORITY
	CONTRACTUAL AFM 2-4	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANAL	GROUP TEST		
2.3 MAINTENANCE, REPAIRS AND REPLACES (CONT'D)	6.3.3.3		UNITS DESTROYED FOR REMOVAL AND REPLACEMENT SHOULD BE PROVIDED WITH HANDLES OR OTHER SUITABLE PROVISIONS FOR GRASPING, MANEUVERING, AND CARRYING.	ARM-5015 B REPAIRS SHOULD BE PROVIDED ON ALL VOME SPIND SECTIONS FOR EAST AND WEST HANDLING.	THE TOWERS CONNECTION OF THE SPINDS OFFERS A SATISFACTORY ALTERNATIVE FOR REPAIRS.	1		NOT APPLICABLE	30
2.4 HANDLING, POSITIONING, LIFTING	6.3.3.3		THE WEIGHT OF A UNIT MUST BE CONSIDERED TO DETERMINE ITS PORTABILITY BY ONE OR TWO MEN.	THE MOVING MAINTENANCE STATION VARY IN WEIGHT FROM 72 TO 95 POUNDS. THE EXISTING MAINTENANCE STATION WEIGHS 130 POUNDS BUT IS DESIGNED WITH CARRYING.	THE WEIGHT OF THE STATION IS NOT EXCESSIVE.	1		NOT APPLICABLE	30
3.0 SAFETY FACTORS									15
3.4 PROTECTION FROM FALLING	7.6		PROVIDE PROTECTION SUCH AS RAILS, AND AROUND FLOOR OPENINGS OR VENTILATION PROTECTORS THAT FALL FROM AN ELEVATION.	ARM 5015 B SP-4-3001	EXCLUSIONS WERE RECOMMENDED FOR THE TOWERS STAIRS. REPAIRS WERE RECOMMENDED FOR THE EXISTING MAINTENANCE STAIRS. IT WAS RECOMMENDED THAT THE PLANE DEFLECTION SAFETY NET BE PERMANENTLY INSTALLED.	1	1	EXCLUSIONS AND HANDRAILS HAVE BEEN PROVIDED.	30
6.0 ENVIRONMENTAL FACTORS									30
6.3 ILLUMINATION	7.21		ADDITIONAL ILLUMINATION SHOULD BE PROVIDED IN ALL WORK AREAS.	ILLUMINATION IN THE AREA OF THE LANDING PLATFORM IS AS LOW AS 5 FT. CANDLE.	BRASS FACTORS RECOMMENDED THAT THE LIGHTING IN THE SILO BE IMPROVED. A STUDY IS TO BE CARRIED OUT BY THE MAINTENANCE COMPANY.	1	1	ILLUMINATION IS NOT ADEQUATE	30

2.1 SYNOPSIS

3.0 DISCUSSION

Consideration should be given to those areas of interface between the missile and launcher that may require special tooling or methods. One prime area for product improvement is the method of installation and torquing of the explosive hold down bolts. Because of limited accessibility, special pneumatic tools should be used wherever possible to permit installation by the minimum number of personnel.

4.0 REFERENCES

1. AFEM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ARDCM 80-6, Handbook of Instructions for Aircraft Ground Support Equipment Designers.
3. WADC TR 52-321, Anthropometry of Flying Personnel.
4. ADS-1003C, Personnel Safety for WS 107A-2 Launcher System.
5. ADS-2018B, Service Platform for WS 107A-2 Launcher System.
6. ADS-5015B, Silo Mouth Platforms, Accessory Work Stand, and Stage I and Stage II Tail Access Work Stands for WS 107A-2 Launcher System.
7. AMF Drawing No. HF-T-1061, Stage I Engine Access Safety Net Study.
8. AMF Document TS 7.2.40, Titan Change Request.

Chapter 19

Human Factors Review and Evaluation
of the
Logic System & Test Equipment

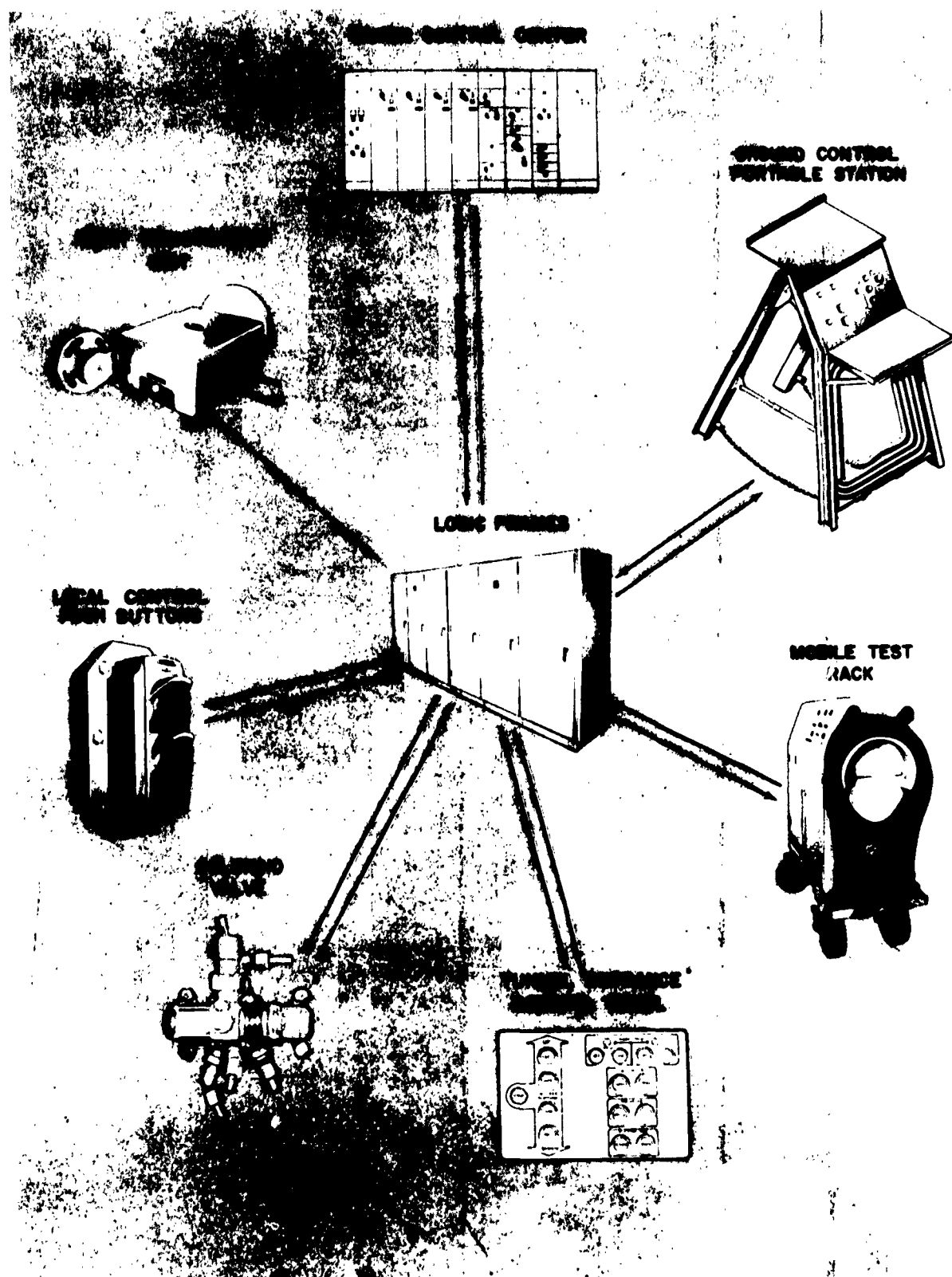


FIGURE 19-1
LOGIC SYSTEM

FAIL-SAFE



System is fail-safe.

FAULT DETECTION



Fault indications should be reduced to a single malfunction and readouts should be simple to decode.

PANEL LOCATION



Panel has been located within optimum area.

PANEL ARRANGEMENT



Controls and displays have been arranged to reduce operating time and to reduce probability of accidental activation.

WARNING DEVICES



Transilluminated displays indicate safe condition for connection and disconnection of plugs.

GROUNDING



A grounded system has been provided.

REMOVE AND REPLACE



Factors contributing to safe and efficient removal and replacement of modules have been included: coding, handles, quick release fasteners, weights.

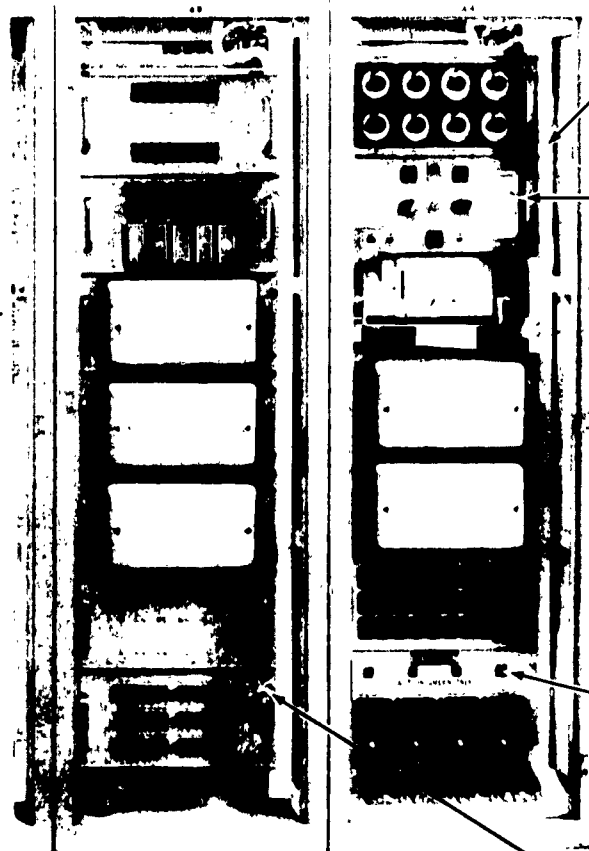


FIGURE 19-2
HUMAN FACTORS INPUTS
LOGIC RACK

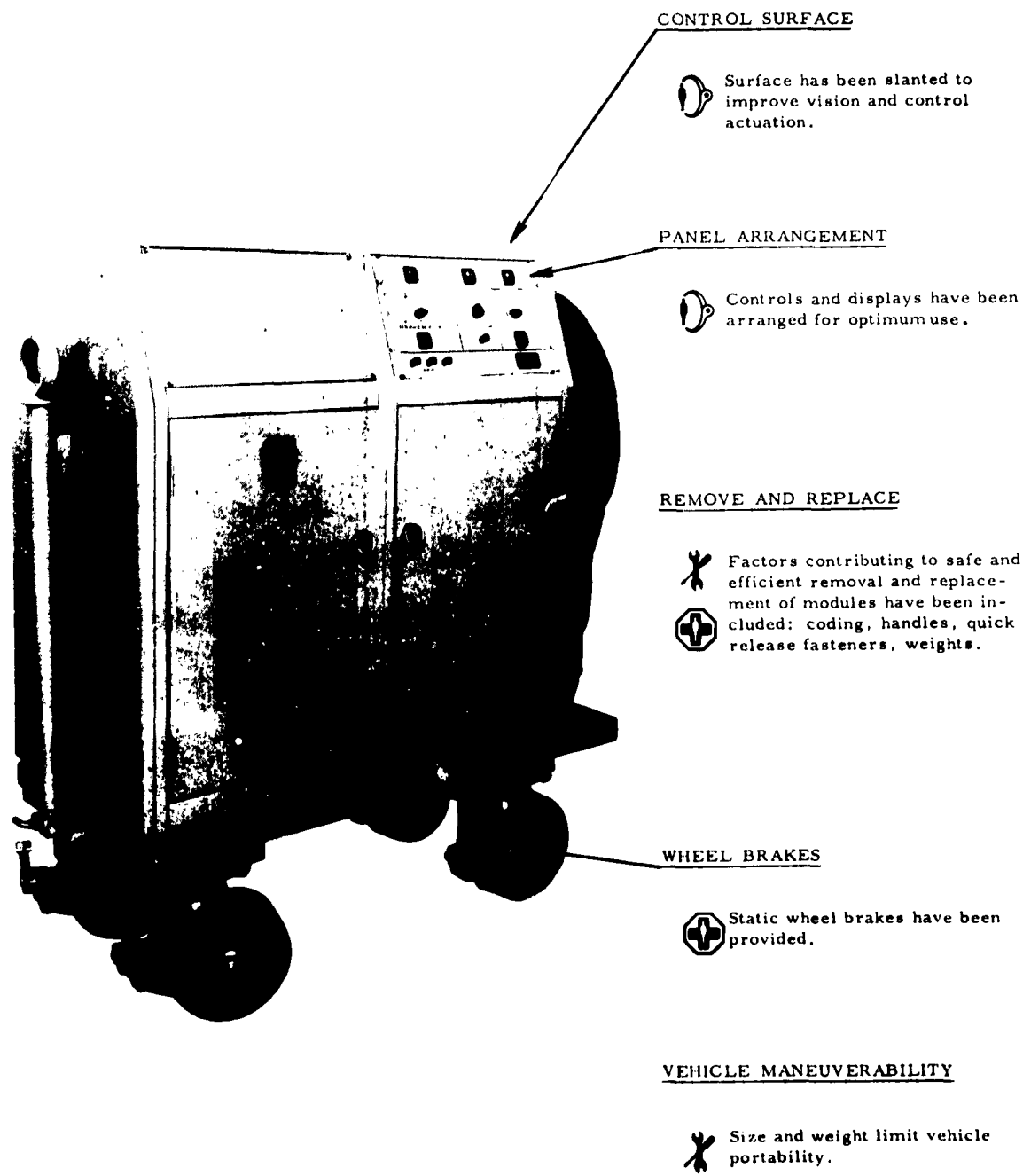


FIGURE 19-3
HUMAN FACTORS INPUTS
MOBILE TEST RACK

**SUMMARY CHECKLIST OF
HUMAN FACTORS PROGRAM
IN RELATION TO:
LOGIC RACK**

	Human Factor Effort Required	PHASE IN STAGE				HUMAN FACTORS OBJECTIVE	APPLICABLE ON MODEL		
		Concept Review	Analysis	Field Input	Specification Compliance		OSTT	TV	OB
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatibility	*	*	*	*	*	*	*	*	*
1.2 Controls and Displays	*	*	*	*	*	*	*	*	*
1.3 Fail-Safe Design	*	*	*	*	*	*	*	*	*
1.4 Malfunction Detection	*	*	*	*	*	*	*	*	*
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual	*	*	*	*	*	*	*	*	*
2.2 Access, Servicing	*	*	*	*	*	*	*	*	*
2.3 Remove and Replace	*	*	*	*	*	*	*	*	*
2.4 Handling, Physical Limitations	*	*	*	*	*	*	*	*	*
2.5 Handling, Transportation	*	*	*	*	*	*	*	*	*
2.6 Vehicle Maneuverability	*	*	*	*	*	*	*	*	*
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination	*	*	*	*	*	*	*	*	*
3.2 Escape Provisions	*	*	*	*	*	*	*	*	*
3.3 Protection from Entanglement	*	*	*	*	*	*	*	*	*
3.4 Protection from Falling	*	*	*	*	*	*	*	*	*
3.5 Safety Devices (other)	*	*	*	*	*	*	*	*	*
3.6 Warning Devices	*	*	*	*	*	*	*	*	*
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Data	*	*	*	*	*	*	*	*	*
4.2 Vertigo	*	*	*	*	*	*	*	*	*
4.3 Vibration Effects	*	*	*	*	*	*	*	*	*
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights	*	*	*	*	*	*	*	*	*
5.2 Fear of Being Crushed	*	*	*	*	*	*	*	*	*
5.3 Fear of Falling	*	*	*	*	*	*	*	*	*
5.4 Fear of Isolation	*	*	*	*	*	*	*	*	*
5.5 Feeling of Insecurity	*	*	*	*	*	*	*	*	*
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)	*	*	*	*	*	*	*	*	*
6.2 Humidity & Temperature	*	*	*	*	*	*	*	*	*
6.3 Illumination	*	*	*	*	*	*	*	*	*
7.0 HUMAN USE FACTORS									
7.1 Procedure	*	*	*	*	*	*	*	*	*
7.2 Time Study	*	*	*	*	*	*	*	*	*
7.3 Training/Selection	*	*	*	*	*	*	*	*	*

FIGURE 19-4

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: MOBILE TEST RACK									
		Human Factor Effort Required				PHASE IN STAGE	HUMAN FACTORS OBJECTIVE	APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation	Product Improvement	OSTF TF	OB
		SYMBOL							
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1	Anthropometric Compatability	*	*	*	*	*	*		
1.2	Controls and Displays	*	*	*	*	*	*		
1.3	Fail-Safe Design	*	*	*	*	*	*		
1.4	Malfunction Detection								
2.0 MAINTENANCE FACTORS									
2.1	Access, Visual	*	*	*	*	*	*		
2.2	Access, Servicing	*	*	*	*	*	*		
2.3	Remove and Replace	*	*	*	*	*	*		
2.4	Handling, Physical Limitations	*	*	*	*	*	*		
2.5	Handling, Transportation								
2.6	Vehicle Maneuverability	*	*	*	*	*	*		
3.0 SAFETY FACTORS									
3.1	Chemical Decontamination								
3.2	Escape Provisions								
3.3	Protection from Entanglement								
3.4	Protection from Falling								
3.5	Safety Devices (other)	*	*	*	*	*	*		
3.6	Warning Devices								
4.0 PHYSIOLOGICAL FACTORS									
4.1	Biological Damage								
4.2	Vertigo								
4.3	Vibration Effects								
5.0 PSYCHOLOGICAL FACTORS									
5.1	Fear of Heights								
5.2	Fear of Being Crushed								
5.3	Fear of Falling								
5.4	Fear of Isolation								
5.5	Feeling of Insecurity								
6.0 ENVIRONMENTAL FACTORS									
6.1	Acoustic Energy (noise)								
6.2	Humidity & Temperature								
6.3	Illumination								
7.0 HUMAN USE FACTORS									
7.1	Procedure								
7.2	Time Study								
7.3	Training/Selection								

FIGURE 19-5

1.0 DESCRIPTION

1.1 In this chapter, the human factors will be considered which are pertinent to the design of the logic system including the Logic Racks and the Mobile Test Rack. The logic system provides sequential control for each equipment operation within the launcher system. The Launch Controller in the Command Control Center furnishes command signals to initiate each sequence. At the completion of a sequence, limit switches within the launcher system close and provide return signals to the Launch Controller logic system. These signals indicate the action has been completed and the next step can be started. No human inputs are required during the full automatic cycling of the launcher. Individual sub-systems can also be operated by the logic system. In this mode, push buttons at the local control station are used by an operator to provide the appropriate command signals to the logic system.

The Launch Controller also furnishes time check signals to monitor the system response. A system malfunction or a sequence which is not completed within the required time causes the system to shut down. The launcher is then returned through the reverse cycle to its hard state position.

In order to provide maintenance crews with the information they must have regarding the exact description and location of a malfunction, the logic system has been connected to additional circuitry which detects, locates and records malfunctions. The circuitry operates only if the logic system is exercised. Should a fault occur while the launcher is being controlled by the Launch Controller, the entire system will shutdown and a fault tape will be punched describing the function which failed, the type of failure, and the location (launcher components or relays).

If at any time, maintenance crews wish to obtain additional tape readings without exercising the entire system they may do so by following a simulated test procedure, using special equipment which simulates Launch Controller commands and launcher component responses from the Operating Test Control Panel. During this procedure the launcher components are disconnected from the logic system and the fault tape can be used to detect faults within the relay system. A Fault Test Program has also been provided to check out the operability of the fault detection and recording system.

The simulating circuitry can be used while the logic system is connected to the launcher components to exercise the actual launcher from the Operating Test Control Panel. All sequences except firing and water spray can be exercised in this manner.

At the TF installation, the logic circuitry, the fault detection circuitry, and the test equipment are all located in the Logic Racks. The logic system at the OSTF installation is of the same design as at TF with the exception that the test equipment is located in a Mobile Test Rack.

1.2 Description of Logic Racks for TF & OB Installations

The Logic Racks provide a central location for the chassis which contain the logic system components such as the circuit breakers, relays, timers, counters, and connectors. Frames serve as structural elements to support the individual chassis, the connector strips, and the panels, which make up the back sides and doors. Separate covers, equipped with quick release fasteners, protect the relays mounted on each chassis.

In TF and in all OB installations the Directory Panel and the Operating Test Control Panel are integrated into one compartment of the Logic Racks along with the fault readout (tape punch) and the Connector Chassis.

1.2.1 Applicable Human Factor Considerations for the Logic Racks

The Logic Racks must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls on the operating panel must be located so as to reduce the probability of operator error and the system must be interlocked against damage from any human error which might occur. The fault detection circuitry should enable the operator to check the equipment prior to and during operation, localize faults to single components, and check the fault detection circuitry itself. Design techniques should be used to simplify the maintenance task.

Factors contributing to the successful use of the Logic Racks have been itemized on the Summary Checklist (Fig. 19-4) and the progress of the equipment design has been tabulated in detail in the following Synopsis.

1.3 Description of Mobile Test Rack for OSTF Only

The Function Blocks (relay sub-system) located within the Logic Racks require the following signals in order to perform any exercise.

1. Limit switch closures within the Launcher: The limit switch closures provide "action completed" signals to the Function Relays (within the Logic Chassis) which in turn provide the signal required to start the next step in the sequence.
2. Command signals from the Launch Controller (located in the Command Control Center); These signals start each sequence in the operation.
3. Time monitoring signals from the Launch Controller (located in the Command Control Center); These signals are sent when the time interval for each sequence is completed. They are used by the AMF Launcher Controller to detect, locate, and register a fault and produce a Launcher NO - GO signal if the "sequence completed" signal is not sent.

The Fault Detection and Readout System will detect or record a malfunction only when the Function Blocks are exercised in some way. In order to exercise these Function Blocks while the Launcher lies dormant in the hard state, it is necessary to simulate the above mentioned signals.

The Mobile Test Rack provides a movable housing for the equipment necessary to provide these signal simulations. For a complete description of this equipment in its relationship to the Logic Racks as well as the human operator refer to the "Man-Machine Analysis of the Portable Test Rack" in the Appendix, Vol. III. An explanation of the 3 volt system used in test procedures is also provided.

1.3.1 Applicable Human Factor Considerations for the OSTF Mobile Test Rack

The OSTF Mobile Test Rack must be designed for operation by Air Force personnel between the 5th and 95th percentile. In order to accomplish this end the following human factors criteria should be considered:

1. Portability - unit should be limited in size and weight to allow for easy handling through doorways, corridors, tunnels, and on ramps, and on elevators.
2. Control and display area - The control and display surface should slant away from the operator so that the center of the panel is perpendicular to the operator's standing line of sight (optimum for 50th percentile). The front edge of this surface should be at an optimum height for an operator in the 5th percentile).
3. Locking wheels - All wheels or castors should be of the locking type so that unit may be secured during operation and while in storage.
4. Indicator lights - Colors must be compatible with designations used throughout the system.
5. Component replacement - Components should be removable without the necessity of removing other components or equipment.
6. Operator compatibility - Any operators with a basic understanding of the system should be able to make optimum use of this test equipment without making human input errors. In order to accomplish this, the selection and placement of control and displays should be based upon the operator's input-output requirements as the human component in the system.

ITEM: LOSS INDEX		DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	ITEM NUMBER
HUMAN FACTORS	CONSTRUCTIONAL ATTENTION	TECH REF	PARTICIPATION		RECOMMENDATIONS	ANALYSIS/TEST				
1.0 HUMAN ENGINEERING DESIGN FACTORS										
1.1 ANTHROPOMETRIC COMFORTABILITY	PAR. 4.1.1	REDESIGN RECOMMENDATIONS		CONTROL PANEL SHOULD BE DESIGNED 60.3" AND 66.3" ABOVE THE GROUND TO INCLUDE 95 % OF THE POPULATION.	DESIGNED REVIEW AND DESIGN CONFERENCE.	CONTROL PANEL LOCATION IS APPROPRIATE WITH REFERENCE TO REQUIREMENTS.	1	1	RECOMMENDATIONS ACCEPTED.	5
1.2 CONTROLS AND DISPLAYS	PAR. 3.1.1			1. HUMAN AND MACHINE CONTROLS TO BE DESIGNED FOR EASY OPERATION. 2. HUMAN CONTROLS TO BE DESIGNED FOR EASY OPERATION. 3. HUMAN CONTROLS TO BE DESIGNED FOR EASY OPERATION. 4. HUMAN CONTROLS TO BE DESIGNED FOR EASY OPERATION. 5. HUMAN CONTROLS TO BE DESIGNED FOR EASY OPERATION.	DESIGNED REVIEW AND DESIGN CONFERENCE. AF, TECHNICAL UTILITY (72 21 APRIL 1978 PROVIDING INFORMATION ON PANEL FRONT LAYOUT.	RECOMMENDATIONS ON CONTROL PANEL WERE MADE IN ACCORDANCE WITH AFN 51-44. FURTHER DATA IS DEVELOPED IN EXISTING COORDINATE. THE CONTROL DESIGNER HAVE BEEN ADVISED TO THAT THE OPERATOR MUST BE ABLE TO REACH TO LEFT. THIS REQUIREMENT INCREASES READING TIME AND DESIGN COMPLEXITY. THESE DESIGN RECOMMENDATIONS CAN BE MADE FROM LEFT TO RIGHT.	1		THE CONTROL AND DISPLAY AREAS FOR THE OPERATOR ARE DESIGNED TO BE SUCH THAT THE OPERATOR CAN SEE ALL CONTROLS AND INDICATORS AT ALL TIMES.	10
1.3 FAIL SAFE DESIGN	PAR. 1.4			SYSTEM SHOULD BE DESIGNED TO AVOID ANY HAZARD. SYSTEM SHOULD BE SUCH THAT HAZARD						

ITEM: JOSTE INKES									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	JOSTE INKES
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
2.4 BUILDING, PHYSICAL LIMITATIONS	PAR. 6.3.3.1		WARNING DEVICES ARE LISTED FOR REMOVABLE COMPONENTS. ARE 2.4 OF THESE THAT HAVE BEEN SPECIFIED.	DESIGN REVIEW AND DESIGN CONFERENCE.	REMOVABLE COMPONENTS SHOULD MEET THE WEIGHT REQUIREMENTS SPECIFIED IN THE CRITERIA FOR DESIGN.		X	ADOPTED.	5
3.0 SAFETY FACTORS									
3.5 SAFETY DEVICES (OTHER)	PAR. 7.0	AMA G-33.8 1957 AMA G-2.4 1959	THE SYSTEM SHALL BE PROBABLY CHANGED.	DESIGN SPECIFICATION AM-3011 30 NOV. 1959	A CHANGED SYSTEM WAS SPECIFIED.		X	ADOPTED.	5
			CRASH AGAINST INADEQUATE ATTENTION.	PERFORMED SAFETY SPECIFICATION AM-3002 29 JUNE 1959	DESIGN REQUIREMENTS TO PREVENT INADEQUATE ATTENTION WERE CARried OUT IN PERSONNEL TRAINING AND EQUIPMENT DESIGN.		X	ADOPTED.	5
3.6 WARNING DEVICES	PAR. 7.2 & 7.3		PERFORMED WARNING DEVICES TO REDUCE THE POSSIBILITY OF HUMAN ERROR.	DESIGN CONFERENCE AND DESIGN REVIEW.	TRANSMISSIONS DEVIATES INDICATE SAFE CONDITION FOR CONNECTION AND DISCONNECTION OF PLUG IN CONNECTOR CHANNEL.		X	ADOPTED.	5
									100

[illegible]

ITEM: BOWEN SRR BACK ENCL 007									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	PRIORITY
	CONTRACTUAL ATTN 51-44	TECH REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
1.3 PAUL SAFE DESIGN	PAR. 2.3.3.1.2 (CONT'D)		DESIGN: BOWEN SRR BACK ENCL 007 DESIGN: TRANSITION DESIGN: COMPLETION DESIGN: IN PROGRESS DESIGN: INFORMATION EFFORTS SHOULD BE MADE TO ACHIEVE A PAUL SAFE DESIGN.	REF DOCUMENT ENCL 2/8 - SLS SYSTEM OF ELECTRICAL SUBSYSTEMS TO DETERMINE THE OPTIONS OF EACH WHILE DESIGN CONSIDERATION IS IN THE LOCAL THERMAL CONTROL RELATIONS IN LAMINATE AND ASSOCIATED EQUIPMENT MOVEMENTS.			1	SYSTEM IS PAUL SAFE AND INTERLOCKED AGAINST DESIGN ERROR.	15
		PAR. 1.4							
2.0 MAINTENANCE FACTORS									
2.1 ACCESS, VIEWING	PAR. 2.3.3.1.2		VIEWING ACCESS SHOULD BE PROVIDED. THE PROVIDED VIEWING IS AN OPENING WITH NO COVER.	DESIGN: REVIEW.	DESIGN: ACCESS AND EGRESS-OUT ACCESS HAVE BEEN RECOMMENDED.		1	ADOPTED.	5
2.2 EGRESS-REPLACEMENT	PAR. 2.3.3.2		REQUIREMENTS FOR ATTACHMENT OF COMPONENTS ARE DETAILED (SEE REFERENCES).	DESIGN: REVIEW.	RECOMMENDATIONS HAVE BEEN IN ACCORDANCE WITH EGRESS 51-44 REQUIREMENTS AND QUICK RELEASE FASTENERS FOR COVER, COVER PLANS AND LIMITED CABLE LENGTHS HAVE BEEN RECOMMENDED.		1	ADOPTED.	10
	PAR. 2.3.3.3		REQUIREMENTS FOR ACCESSIBILITY OF COMPONENTS ARE DETAILED (SEE REFERENCES).						

ITEM: MONTHS TEST BASE FOR Q987																														
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS																						
	CONTRACTUAL	TECH REF		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST																							
2.1 HANDLING, PHYSICAL LIMITATIONS	PAL. 6.3.3.1		MAXIMUM WEIGHT TO CARRY: 25 LBS. SPECIAL HANDLING REQUIREMENTS MUST BE PROVIDED IF THE FOLLOWING WEIGHT-HEIGHT VALUES ARE EXCEEDED: <table><tr><td>WGT.</td><td>HEIGHT</td><td>MAX. WEIGHT</td></tr><tr><td>1 FOOT</td><td>145 LBS.</td><td></td></tr><tr><td>2 FEET</td><td>130 LBS.</td><td></td></tr><tr><td>3 FEET</td><td>77 LBS.</td><td></td></tr><tr><td>4 FEET</td><td>55 LBS.</td><td></td></tr><tr><td>5 FEET</td><td>34 LBS.</td><td></td></tr><tr><td>6 FEET</td><td>20 LBS.</td><td></td></tr></table> USE AND WEIGHT SHOULD BE AS SO THAT THE UNIT CAN FULLY BE MOVED THROUGH DOORWAYS, CORRIDORS, TUNNELS, AND ON RAMP AND ELEVATORS.	WGT.	HEIGHT	MAX. WEIGHT	1 FOOT	145 LBS.		2 FEET	130 LBS.		3 FEET	77 LBS.		4 FEET	55 LBS.		5 FEET	34 LBS.		6 FEET	20 LBS.		DETAILED REVIEW.	REPAIRABLE COMPONENTS SHOULD MEET THE WEIGHT REQUIREMENTS SPECIFIED IN THE CRITERIA FOR SUCCESS.			ADAPTED	5
WGT.	HEIGHT	MAX. WEIGHT																												
1 FOOT	145 LBS.																													
2 FEET	130 LBS.																													
3 FEET	77 LBS.																													
4 FEET	55 LBS.																													
5 FEET	34 LBS.																													
6 FEET	20 LBS.																													
2.2 VEHICLE MANEUVERABILITY			USE AND WEIGHT SHOULD BE AS SO THAT THE UNIT CAN FULLY BE MOVED THROUGH DOORWAYS, CORRIDORS, TUNNELS, AND ON RAMP AND ELEVATORS.	DETAILED REVIEW.	REPAIR FACTORS RECOMMENDED WEIGHT AND SIZE LIMITATIONS TO INSURE VEHICLE PORTABILITY.	1	1	VEHICLE COULD NOT EASILY BE MOVED THROUGH DOORWAYS (THE EQUIPMENT BEING MOVED WAS OF 1000 LBS. AT 17 AND 18 INCHES.)	10																					
3.0 SAFETY PRECISE																														
3.5 SAFETY DEVICES (OTHER)	PAL. 7.5		SELF-LOCKING DEVICES SHOULD BE USED TO PREVENT ACCIDENTAL OR UNAUTHORIZED MOVEMENT.	DETAILED REVIEW.	WEIGHTS AND CAPTURES ON THE VEHICLE TEST RACK SHOULD BE OF THE LOCKING TYPE SO THAT IT CAN BE REMOVED DURING OPERATION AND STORAGE.		1	ADAPTED	10																					

3.0 DISCUSSION

Logic Racks

The recommendations for the design of the Logic Racks were tabulated in the preceding synopsis. The two improvements that could be made in the design of the logic system, from the human factors standpoint, are in the fault detection system and by eliminating the necessity for the operator to read the printed data from right to left.

OSTF Mobile Test Rack

Original concepts provided for portable test equipment which would serve an entire complex to comply with austerity requirement of AFBMD. When the prototype (OSTF) model of the Mobile Test Rack was completed and designs for corridors, ramps, doorways and tunnels were established the advisability of such a concept was found questionable. Facility traffic provisions made the movement of this equipment between Equipment Silos extremely impractical.

A change in scope for TF & OB installations resulted in an improvement to this situation by providing each launcher with separate test equipment housed compactly within the Logic Racks in the Electrical Room of each Equipment Silo.

This change of scope provided an opportunity to use the Man-Machine Analysis of the Mobile Test Rack as a guide to improve human factors in the design of a new Operating Test Control Panel. This equipment was the result of close cooperative effort between human factors engineering and the electrical hardware group.

4.0 REFERENCES

1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ASA C-2.4-1939, Safety Rules for the Operation of Electrical Equipment and Electrical Lines.
3. ASA C-33.8-1957, Grounding and Safety Equipment.
4. ADS-3014B, Design Specification-Chassis, Panels, Distribution Frames and Test Rack for WS 107A-2 Launcher System, 30 Nov. 1959.
5. ADS-1003C, Personnel Safety for WS-107A-2 Launcher System, 29 June 1959.
6. AMF Document, Technical Bulletin, #72, Human Engineering of Panel Fronts, 4/21/58.
7. C. Besserer, Missile Engineering Handbook, New York, D. Van Nostrand Company, Inc., 1958, page 378.
8. AMF Report, ER-T/S-5116, Human Factors Analysis of the Titan Launcher System, 4/5/61.
9. Becker & Becker Drawing AMF-E-3 & Report of 31 June 1958.

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Tunnel Entrance & Ground Level Control Stations Chapter 20

LOCATION



The unit is located so that missile components do not pass over the operator during missile loading.

WEATHER COVER

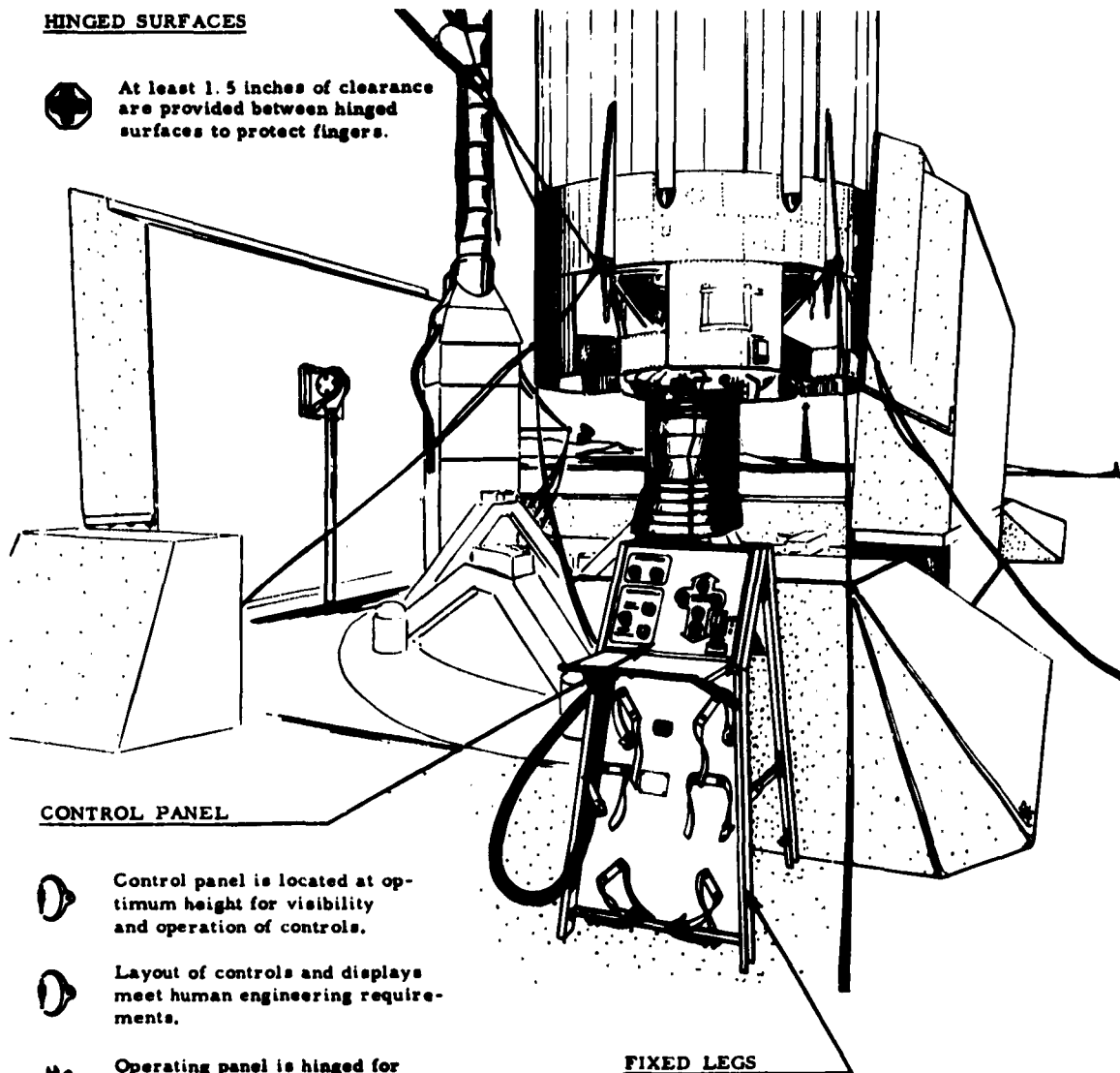


A weather cover is recommended for protection against the elements.

HINGED SURFACES



At least 1.5 inches of clearance are provided between hinged surfaces to protect fingers.



CONTROL PANEL



Control panel is located at optimum height for visibility and operation of controls.



Layout of controls and displays meet human engineering requirements.



Operating panel is hinged for access to the interior and the wiring.

FIXED LEGS



Fixed legs are provided for stand-up operation of the unit.

FIGURE 20-1
HUMAN FACTORS INPUTS
GROUND LEVEL PORTABLE CONTROL STATION

ILLUMINATION



Glare proof lighting is recommended.

CONTROL PANEL



Control panel is mounted too low for optimum visibility and operation.



Layout of controls and displays meets human engineering requirements. All pushbuttons should be illuminated when function has been completed.



Operating panel is hinged for access to the interior and the wiring.



Panel light is provided to indicate power pack operation.

LOCATION



Unit is located where it does not interfere with tunnel to bridge traffic.

INTERLOCKS



Functions controlled by this and associated local stations are interlocked against human errors.

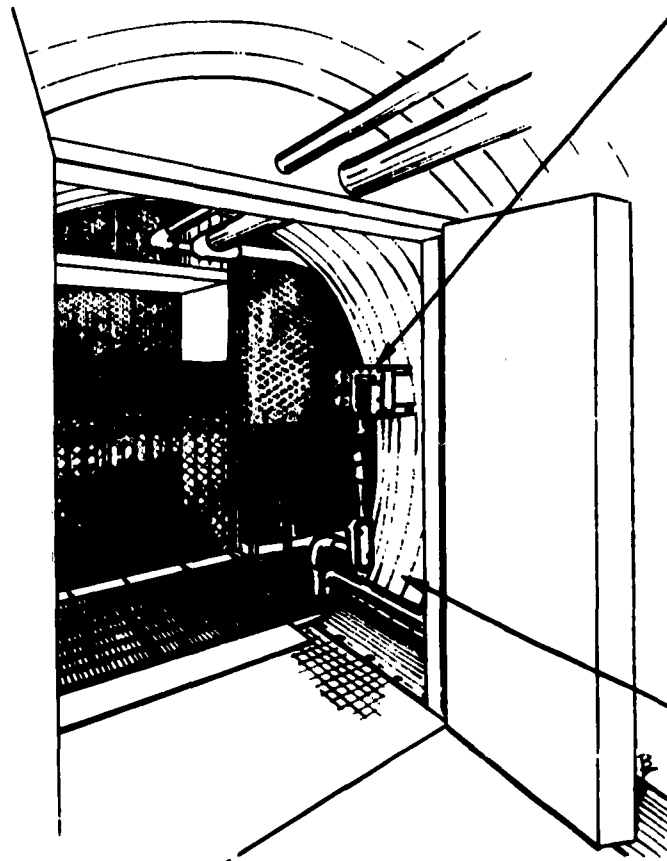


FIGURE 20-2
HUMAN FACTOR'S INPUTS
TUNNEL ENTRANCE CONTROL STATION

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: GROUND LEVEL CONTROL STATION									
	Human Factor Effort Required	PHASE IN STAGE			HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation	Product Improvement OSTF TF OB		
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability	*	*		*	*		*	*	
1.2 Controls and Displays	*	*		*	*		*	*	
1.3 Fail-Safe Design	*								
1.4 Malfunction Detection									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual									
2.2 Access, Servicing	*	*				*	*	*	
2.3 Remove and Replace						*	*	*	
2.4 Handling, Physical Limitations	*	*				*	*	*	
2.5 Handling, Transportation	*		*			*	*	*	
2.6 Vehicle Maneuverability									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination									
3.2 Escape Provisions									
3.3 Protection from Entanglement									
3.4 Protection from Falling									
3.5 Safety Devices (other)	*	*			*		*	*	
3.6 Warning Devices									
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling	*	*			*		*	*	
5.4 Fear of Isolation								*	
5.5 Feeling of Insecurity	*	*			*		*	*	
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature	*	*			*		*	*	
6.3 Illumination	*	*		*	*		*	*	
7.0 HUMAN USE FACTORS									
7.1 Procedure									
7.2 Time Study									
7.3 Training/Selection									

FIGURE 20-3

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: TUNNEL ENTRANCE CONTROL STATION									
	Human Factor Effort Required	PHASE IN STAGE			HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation Product Improvement	OSTF	TF	OB
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability	*	*		*	*		*	*	*
1.2 Controls and Displays	*	*		*	*		*	*	*
1.3 Fail-Safe Design	*		*		*		*	*	*
1.4 Malfunction Detection									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual									
2.2 Access, Servicing	*	*				*	*	*	*
2.3 Remove and Replace									
2.4 Handling, Physical Limitations									
2.5 Handling, Transportation									
2.6 Vehicle Maneuverability	*	*		*	*		*	*	*
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination									
3.2 Escape Provisions									
3.3 Protection from Entanglement									
3.4 Protection from Falling									
3.5 Safety Devices (other)	*	*					*	*	*
3.6 Warning Devices									
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling	*	*			*		*	*	*
5.4 Fear of Isolation									
5.5 Feeling of Insecurity									
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature									
6.3 Illumination	*	*		*	*		*	*	*
7.0 HUMAN USE FACTORS									
7.1 Procedure									
7.2 Time Study									
7.3 Training/Selection									

FIGURE 20-4

1.0 DESCRIPTION

In this chapter the human factors will be considered which are pertinent to the design and installation of the Ground Level Portable Control Station and the Tunnel Entrance Control Station.

1.1 Ground Level Portable Control Station

1.1.1 Description

The Ground Level Portable Control Station is used during the stage handling task to operate the launcher platform and may also be used to test the water spray system during periodic maintenance checks. This station is portable with a fifty foot cable extension and is mounted on fixed legs for stand-up operation. The connection of this station into the system disables the Tunnel Entrance Control Station. The Ground Level Portable Control Station is not operable unless the following conditions are satisfied:

- a) It is plugged into the connection box,
- b) The Cycling Control Station master switch is not in the local position,
- c) The system safety interlocks permit equipment actuation, and
- d) The circuit breakers in the Motor Control Station are closed.

1.1.2 Applicable Human Factor Considerations

The Ground Level Portable Control Station must be designed for operation by Air Force personnel between the 5th and 95th percentile. The unit must be transportable and access must be provided to components and wiring. The station should be located so that the operator is not too close to the silo opening and missile components do not pass over his head during loading. Consideration should be

given to the use of the unit at night and during inclement weather. Controls and displays must be located so as to reduce the probability of operator error.

1.2 Tunnel Entrance Control Station

1.2.1 Description

The Tunnel Entrance Control Station is used for local control of the Launcher Platform before and after stage handling and for periodic maintenance checks. This station is located at the entrance of the personnel tunnel into the silo.

The Tunnel Entrance Control Station is not operable unless the following conditions are satisfied:

- a. the Ground Level Portable Control Station is not connected,
- b. the Cycling Control Station master switch is not in the local position,
- c. the system safety interlocks permit equipment operation, and
- d. the circuit breakers in the Motor Control Station are closed.

1.2.2 Applicable Human Factor Considerations

The Tunnel Entrance Control Station must be designed for operation by Air Force personnel between the 5th and 95th percentile. Controls and displays must be located so as to reduce the probability of operator error. Access must be provided to components and wiring. The station must be designed and located so that it does not interfere with the passage of vehicles through the tunnel and across the Crib-to-Silo Bridge. Consideration should be given to lighting and fail safe design.

ITEM: CROWN LEVEL PORTABLE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	RELATIVE PRIORITY
	CONSTRUCTIONAL PARTS 2-4A	TECH REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS TEST			
1.0 INPUT ENLIGHTENING DESIGN FACTORS 1.1 OUTPUT-METHOD COMPARABILITY	PAB. 6.1		THE MONITORING METHOD OF CONTROLS AND DISPLAYS, THE HEIGHT OF THE MONITOR SURFACE, AND THE SIZE OF THE PANEL SURFACES SHOULD PERMIT OPERATION BY TWO OF THE POPULATION.	TRAINING REVIEW HQ-479-173 2-13-59.	1. THE MONITOR SURFACE SHOULD BE ADJUSTED VERTICALLY TO 30° BELOW A LINE PARALLEL TO THE GROUND. 2. THE PANEL SURFACES SHOULD BE 90° ± 10° TO THE LINE OF SIGHT. (AT PANEL CENTER) 3. THE PANEL SURFACE SHOULD BE 80° FROM THE EYE POSITION OF THE USER PRESENTLY (4L, P) ON A LINE 10° FROM THE NORMAL LINE OF SIGHT.	I	ADOPTED.	10	
1.2 CONTROLS AND DISPLAYS	PAB. 3.1.3 PAB. 3.1.4 PAB. 3.2.1		LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION. ADVISE CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY. PRESENTATIONS SHOULD BE DESIGNED WITH A. RADIUS DIAMETER OF 1/8" B. DISPLACEMENT OF 1/8" TO 1/4" C. RESISTANCE OF 10 TO 15 GRAMS, AND D. ADVISE CLIP TO INDICATE ACTIVATION.	TRAINING REVIEW HQ-479-180 9/4/59. WF-8-1360 WF-8-1366	RECOMMENDATIONS ON CONTROL LAYOUT WERE MADE.	I	ADOPTED WITH EXCEPTION OF PRESENTATIONS WHICH ARE REFINES LIMITED FOR INCLUDE AS MINIMAL CLIP TO INDICATE ACTIVATION.		

ITEM: GROUND LEVEL PORTABLE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	SYNOPSIS
	CONTINUING	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
2.0 MAINTENANCE FACTORS 2.2 ACCESS, SERVICING	PMB 4.3.3.7		EDUCED FAL... ACCESS SHOULD BE PROVIDED.	DRAWING REVIEW 12-776-156 12-10-98	A REVIEW OPERATING PANEL FOR ACCESS TO THE INTERIOR AND WHEEL RIMMERS FOR LIFTING AND CANNISTER WERE RECOMMENDED.		1	ADOPTED.	20
2.3 HANDLING, PHYSICAL LIMITATIONS	PMB 4.3.3.3		SPECIAL HANDLING EQUIPMENT SHALL BE PROVIDED FOR CHARTING AND HANDLING.	DRAWING REVIEW 12-776-158 12-10-98			1	ADOPTED.	20
2.5 HANDLING, TRANSPORTATION	PMB 4.3.3		SPECIAL HANDLING EQUIPMENT SHOULD BE PROVIDED FOR WHEELS TOO HEAVY TO BE CARRIED BY ONE MAN.	DESIGN CONFERENCE TO IMPLEMENT FIELD REQUEST.	FIELD REQUESTED WHEELS TO IMPROVE PORTABILITY.		1	ADOPTED.	20
3.0 SAFETY FACTORS 3.5 SAFETY SYSTEMS	PMB 7.0		PROVIDE CLEARANCE FOR FIREARMS BEHIND KINEMATIC SURFACES.	DRAWING REVIEW 12-776-173 2-11-99	A CLEARANCE OF 19 INCHES BETWEEN SURFACES WAS RECOMMENDED.		1	ADOPTED.	20
	PMB 3.1.3		STRENGTHEN THE SYSTEM AGAINST DISCOMFORT OPERATIONS BY PROVIDING AN ONE SEATON WITH OPERATIONS AND BEING INITIATED AT ANOTHER SEATON.	DESIGN CONCEPT MEETING. REVIEWED AS PART OF SMALL FACTORS ANALYSIS OF THE SYSTEM LAUNCHER SYSTEM.	SEAL FACTORS RECOMMENDING REQUESTED INTERLOCKED SWITCH WOULD MAKE THE TUNNEL ENTRANCE CONTROL STATION COMPLETELY IN-OPERATIVE WITH THE GROUND LEVEL PORTABLE CONTROL STATION WAS CONNECTED. WHILE IT IS OPEN, THE G.L.P.C.S. CONTINUING THE OVERLAP ATTACKS LAUNCH SWITCHES WERE OPEN CLOSING FROM THE TICS TO LAUNCH.	1	1	INTERLOCKS HAVE BEEN PROVIDED.	20
5.0 PSYCHOLOGICAL FACTORS 5.3 FEAR OF FALLING	PMB 7.8		PROTECTION AGAINST FALLING SHOULD BE PROVIDED AROUND OPENINGS.	SYSTEMS ANALYSIS.	THE OPERATOR SHOULD BE LOCATED FAR ENOUGH FROM THE STILL OPENING SO THAT HE EXPERIENCES NO FEAR OF FALLING.		1	OPERATOR IS LOCATED 15' FROM THE STILL OPENING.	5

ITEM: GROUND LEVEL PORTABLE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	RELATIVE RATING
	CONTRACTUAL AFPM 50-5A	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
5.5 FEELING OF INSECURITY	P.A. 7.0		PRECAUTION SHOULD BE TAKEN TO PROTECT THE OPERATOR AND EQUIPMENT DURING SYSTEM OPERATION	SYSTEMS ANALYSIS.	STATION SHOULD BE LOCATED SO THAT THE CRANE ARM DOES NOT PASS OVER THE OPERATOR'S HEAD.		X	ADOPTED.	10
6.0 ENVIRONMENTAL FACTORS 6.2 HUMIDITY AND TEMPERATURE			OPERATOR SHOULD BE PROTECTED AGAINST EFFECTS OF SUN, RAIN, AND SNOW.	TRAINING SECTION.	A WEATHER COVER SHOULD BE PROVIDED FOR PROTECTION AGAINST THE ELEMENTS.		X	NOT ADOPTED.	5
6.3 ILLUMINATION	P.A. 7.2		WORK AREAS SHOULD BE ILLUMINATED BY AT LEAST 25 FOOT CANDLES.	SYSTEMS ANALYSIS.	PROVIDE ADDITIONAL ILLUMINATION FOR OPERATION OF THE STATION AT NIGHT AND ON OVERCAST DAYS.		X	NOT ADOPTED.	10
									100

ITEM: TUNNEL ENTRANCE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA			VERIFICATION		RESULTS
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANALYSIS/TEST			
1.0 EVALUATION DESIGN FACTORS			CONTROL PANEL SHOULD BE BETWEEN 60.3" AND 69.1" ABOVE THE GROUND TO INCLUDE 95% OF THE POPULATION.	WP-4-1007 TUNNEL ENTRANCE CONTROL STATION STUDY INDICATED CONTROL PANEL HEIGHT.	CONTROL PANEL LOCATION IN ACCORDANCE WITH REQUIREMENTS WAS RECOMMENDED.				10
1.1 ANTHROPOMETRIC COMPATIBILITY			1. LOCATE AND DESIGN CONTROLS TO REDUCE PROBABILITY OF ACCIDENTAL ACTIVATION.	WP-4-1004 REVISED T.E.C.S. PANEL LAYOUT.	CRITERIA FOR PROBABILITY WAS TRANSMITTED AND DESIGN ASSURANCE WAS PROVIDED IN THE LAYOUT OF CONTROL PANEL.				10
1.2 CONTROLS AND DISPLAYS			2. ADJUST CONTROLS TO REDUCE OPERATING TIME AND ERROR PROBABILITY.	22-078-02 8-11-98	PANEL SIZE WAS REDUCED.				
			3. PROBABILITY SHOULD BE REDUCED WITH	WP-4-1005 PROBATION A 27 FEB 1960 TUNNEL FACTORS TEST PROCEDURE TUNNEL ENTRANCE CONTROL STATION					
			A. REDUCED WEIGHT OF 1/8 TO 1/4						
			B. DISTANCE OF 10 TO 16 INCHES, AND						
			C. ADJUST CLIP TO						
			INCLUDE ACTIVATION.						
			SYSTEM SHOULD BE MADE TO						
			ADJUST A FALL SAFE DESIGN.						
1.3 FALL SAFE DESIGN				SYSTEM OF ELECTRICAL SCHEMATICS.	WEAR FACTORS ANALYSIS OF TITAN LAUNCHER SYSTEM FOUND NO ADDITIONAL INTERLOCKS TO BE NECESSARY.				10

2.1 SYNOPSIS

ITEM: TUNNEL ENTRANCE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE CONTRACTUAL AFFIRM 52-8A	TECH REF.	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	%
				PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
2.0 MAINTENANCE FACTORS 2.2 ACCESS, SERVICING 2.6 VEHICLE HANDLING/USABILITY	PAR. 4.3.3.9		REMOVED PANELS FOR ACCESS SHOULD BE PROVIDED. THE STATION SHOULD BE DESIGNED AND LOCATED SO THAT IT DOES NOT INTERFERE WITH THE PASSAGE OF VEHICLES THROUGH THE TUNNEL AND ALONG THE CRUISE-TO-SILO METHOD.	DESIGN CONFERENCE AND BRIEFING REVISIONS. SP-5-JUN7 TUNNEL ENTRANCE CONTROL STATION STOVE INDICATED LOCATIONS SUGGESTED BY SENAS FACTORS RECOMMENDATIONS.	A REMOVED OPERATING PANEL FOR ACCESS TO THE INTERIOR AND VEHICLE WAS RECOMMENDED. A NOTIFICATION IN THE LOCATION OF THE TUNNEL ENTRANCE CONTROL STATION WAS RECOMMENDED TO PREVENT VEHICLE PASSAGE.		I	ADOPTED.	15
3.0 SAFETY FACTORS 3.5 SAFETY DEVICES	PAR. 7.2		WARNING DEVICES SHOULD BE PROVIDED FOR THE POSITION OF CRITICAL CONTROLS. INTERFERENCE THE SCREEN ANALYST DISAPPEARANCE OPERATION AT PREVIOUS 2.0 ONE STATION WHILE OPERATIONS ARE BEING INITIATED AT REMOTE STATION.	DESIGN CONFERENCE AND BRIEFING REVISIONS. DESIGN CONCEPT MEETING. REVIEWED AS PART OF SENAS FACTORS ANALYSIS OF THE TUNNEL ENTRANCE STATION. TB-7/8-5116.	LIGHTS WERE RECOMMENDED TO INDICATE POWER PACK OPERATION.		I	ADOPTED.	10
	PAR. 3.1.3				SENAS FACTORS RECOMMENDED REMOVED INTERLOCKS WITH WOULD MAKE THE TUNNEL ENTRANCE CONTROL STATION COMPLETELY INOPERATIVE WHILE THE CRUISE LEVEL PORTABLE CONTROL STATION WAS CONNECTED. WHILE IT IS OPEN, THE G.L.P.C.S. CONNECTION WOULD COVER AIRLIFT LIFT SWITCHES WHICH OPEN CONTROL CIRCULATING FROM THE T.S.C.S. TO LOGIC.		I	INTERLOCKS HAVE BEEN PROVIDED.	10

2.1 SYNOPSIS

ITEM: TUNNEL ENTRANCE CONTROL STATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE	CONTRACTUAL APTN 50-50A	TECH. REF.	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS
					PARTICIPATION	RECOMMENDATIONS	ANAL.	EQUIP. TEST	
5.0 ENVIRONMENTAL FACTORS 5.3 FEAR OF FALLING	PAL 7.0, 7.9 PAL 7.22			PROVIDE HANDRAILS OR SAFETY CHAINS AT OPENING. PROVIDE SKID PROOF FLOORING.	TRAINING SYSTEM. ES-475-116.	IT WAS ANTICIPATED THAT FEAR OF FALLING WOULD BE A PROBLEM FOR THE OPERATOR OF THIS STATION. SAFETY CHAINS, HAND RAIL EXTENSIONS, OPPOSE CHAINS, AND SKID PROOF FLOORING RECOMMENDED.	I	I	THE TUNNEL ENTRANCE CONTROL STATION IS LOCATED SO THAT FEAR OF FALLING IS NOT A PROBLEM DUE TO THE PLACEMENT OF UTILITIES AND OTHER ASSOCIATED CONSTRUCTION EQUIPMENT IN THE AREA.
6.0 ENVIRONMENTAL FACTORS 6.3 ILLUMINATION	PAL 7.23			WORK AREAS SHOULD BE ILLUMINATED BY AT LEAST 25 FOOT CANDLES.	REVIEW OF TUNNEL DIAGRAMS.	SKID LIGHTING WAS FOUND TO BE INADEQUATE.	I		NOT TRANSMITTED A LETTER ON 4/26/79 TO HQ-SEL. SECOND BY A. J. BRYANT ON THE SUBJECT "LIMITING STATION IN RESOLVE SETUP".

3.0 DISCUSSION

Construction of the silo cap, electrical requirements, reliability and safety considerations (50 foot cable length) all dictated the design of the Ground Level Portable Control Station. In order to provide a more compact, more portable unit all of these factors would have to be modified in basic concept.

Early concepts indicated that the Tunnel Entrance Control Station would be located near the Crib-to-Silo bridge and the operator would have a panoramic view of the Silo. For these reasons it was anticipated that fear of falling and a general sense of insecurity might represent problems for the operator. However, in the present system, equipment has been modified and added so that the operator should not experience either a fear of falling or a feeling of insecurity. This problem is referenced in the synopsis since it did represent effort on the program.

4.0 REFERENCES

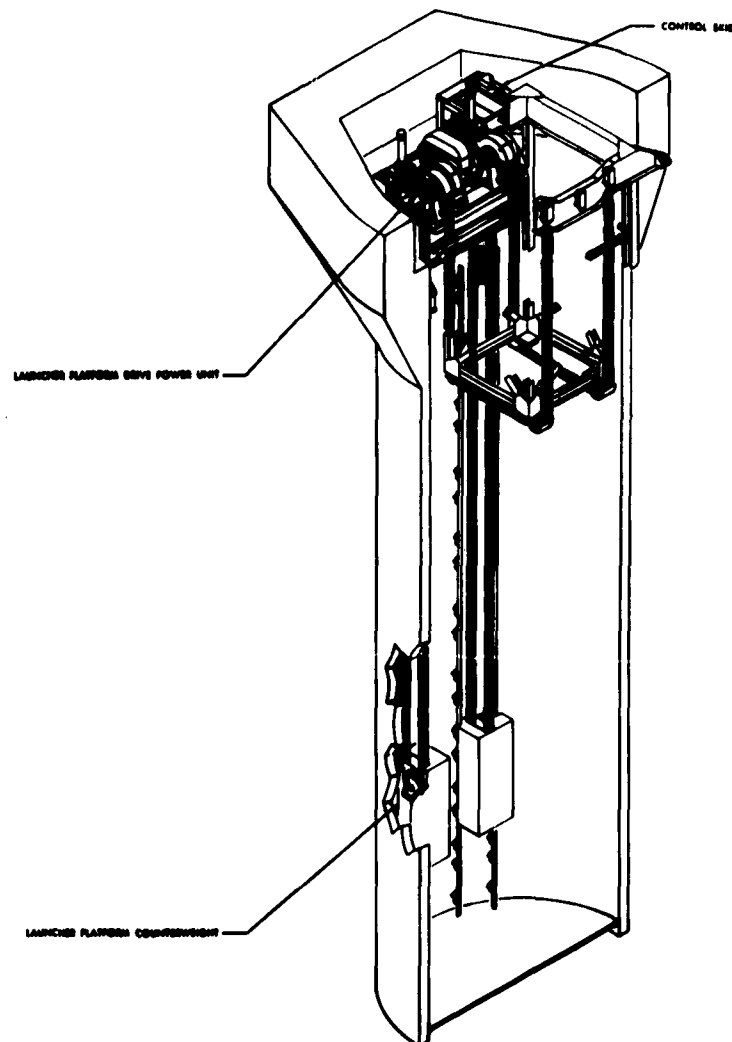
1. AFEM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ADTP-V-2056, Addendum A, Human Factors Test Procedure Tunnel Entrance Control Station.
3. Daniel, Mann, Johnson & Mandenhall and Associates, WS 107A-2, Technical Facilities Mountain Home Air Force Base, Mt. Home, Idaho, Volume I, Sheet #92-E-1; Volume II, Sheets #93-E-1,2.
4. C. Besserer, Missile Engineering Handbook, New York, D. Van Nostrand Company, Inc., 1958, page 378.
5. AMF Report, ER-T/S-5116, Human Factors Analysis of the Titan Launcher System, 4/5/61.
6. AMF Report, ER-TPS-88, Ground Level Control Station Human Engineering Report, 8/6/58.
7. AMF Report, ER-TPS-156, Ground Level Portable Control Station Design Considerations, 12/10/58.
8. AMF Report, ER-TPS-82, Tunnel Entrance Control Station Electrical System, 8/11/58.
9. AMF Report, ER-TPS-146, Tunnel Entrance Control Station, 11/26/58.
10. AMF Drawing HF-T-1160, Ground Level Control Station Layout.
11. AMF Drawing HF-T-1161, Control Station Analysis - Motion Study.

12. AMF Drawing HF-T-1047, Tunnel Entrance Control Station Study.

13. AMF Document, TS 7.2.20, Lighting System in Missile Silo, 6/24/59.

Chapter 21

Human Factors Review and Evaluation
of the
Main Drive System



ACCESS PLATFORM

- ✖ A platform has been provided for servicing the counterweight support mechanism.

COVER GUARD

- ⊕ A cover guard should be provided for the Main Drive Brake to prevent injury from entanglement.

ACCESS

- ⊕ A ladder should be added from platform 1 to provide access to the drive base. A ramp should be provided over the drive base to the catwalk.
- ✖

AUXILIARY DRIVE

- ✖ A jacking motor should be installed as an auxiliary means of activating the Launcher Platform in the event of Main Drive failure.

FIGURE 21-1
HUMAN FACTORS INPUTS
MAIN DRIVE

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: MAIN DRIVE									
	Human Factor Effort Required				PLANS IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL
	Concept Review	Analysis	Field Input	Specification Compliance	Safety	Operational Status	Maintenance Recommendation	Product Improvement	
	OSPP	IT	OB						SYMBOL
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatibility									
1.2 Controls and Displays									
1.3 Fail-Safe Design									
1.4 Malfunction Detection									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual									
2.2 Access, Servicing	*	*				*	*	*	
2.3 Remove and Replace	*	*				*	*	*	
2.4 Handling, Physical Limitations						*	*	*	
2.5 Handling, Transportation	*	*				*	*	*	
2.6 Vehicle Maneuverability									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination									
3.2 Escape Provisions							*	*	
3.3 Protection from Entanglement	*	*			*		*	*	
3.4 Protection from Falling	*	*			*	*	*	*	
3.5 Safety Devices (other)	*	*			*	*	*	*	
3.6 Warning Devices	*	*			*		*	*	
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling									
5.4 Fear of Isolation									
5.5 Feeling of Insecurity									
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature									
6.3 Illumination									
7.0 HUMAN USE FACTORS									
7.1 Procedure									
7.2 Time Study									
7.3 Training/Selection									

FIGURE 21-2

1.0 DESCRIPTION

1.1 In this chapter the human factors will be considered which are pertinent to the design and installation of the Main Drive. The Main Drive system includes the launcher platform drive system and the power transmission unit which work together to raise or lower the missile. The launcher platform drive system is a complete system of counterweights, cables, and support mechanisms that control the vertical movement of the platform and missile at any desired level in the silo. The drive power unit is a separate hydraulically operated motor and gear reducer. Cables of the drive system are fed through the drive sheaves which are geared to the hydraulic motor.

The system of cables and counterweights for the launcher platform drive system consists of two separate sets of elevator cables attached at one end to the top of the crib structure and strung under the launcher platform through idler pulleys, up into the drive sheaves, down again through two sets of counterweight sheaves, and back up into the tension equalizer cylinders which maintain equal tension on the cables as a stability measure to level the platform. The counterweights slide up and down along guide rails mounted to the silo wall.

When the launcher platform is at the base of the missile silo the weight of the leaded counterweights is supported by two support mechanisms attached to the silo wall. When the launcher platform is moved from the base of the silo, the counterweight support mechanisms are stowed so as to bring the full weight of the counterweights on the system.

A counterweight lifting and locking assembly lifts the counterweight while the launcher system is in the hard state, and it imparts slack to launcher

cables during shock conditions in order to maintain a relative motion between the crib and the silo wall.

The launcher platform drive power unit supplies the power to raise the launcher platform and missile to launch attitude or any intermediate position for maintenance purposes. The power unit is located on the silo wall. The motor is a hydraulic pump-type motor that converts hydraulic pressure into rotary mechanical power. The motor incorporates a release brake for stopping or holding the platform at any desired position in the silo. The braking unit can also stop the launcher platform under conditions of hydraulic or mechanical failure. A speed reducer provides low speed, high torque power.

- 1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to perform maintenance on the Main Drive components efficiently and safely. Adequate access must be provided to all equipment. Special handling equipment must be available for all components that cannot be readily removed and replaced by a single operator. The equipment must be designed so that the hazards of falling, entanglement, etc. are minimized.

ITEM: SUB DATA		DOCUMENT COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RESULTS
HUMAN FACTORS	TECHNICAL	TECHNICAL	TECHNICAL		PARTITION	REQUIREMENTS	
2.3 SENSORY-REPLACE	PAR. 4.3.3.1			SENSORY AND REACTION ON WHICH BASIS ONE IS PLACED SHOULD BE PROVIDED.		THE CRITERIA SENSORY BASIS SHOULD BE PLACED WITHIN TO AND IN ALTERNATE OF THE PERIOD AND TO INCLUDE CRITICAL SENSORY.	SEE 2.2.
	PAR. 4.3.3.1			CRITERIA IS ONE OF THE GENERAL PRINCIPLES OF RESPONSE SHOULD BE MAINTAINABILITY.	20-475-50	REQUIREMENTS ARE MAINTAINED TO THE PERIOD FOR THE TYPE AND REPLACEMENT.	SEE 2.2.
				REQUIREMENTS INCLUDE THE REQUIREMENT IS REQUIRED TO PROVIDE FOR SENSORY AND SENSORY, AND REPLACEMENT OF SENSORY AT A SENSORY CRITERIA, IF REQUIRED.	20-475-50 SEE CHAPTER 12 FOR MORE DETAILED INFORMATION.	REQUIREMENTS INCLUDE THE REQUIREMENT IS REQUIRED TO PROVIDE CRITERIA IN THE SENSORY AND REPLACEMENT OF THE SENSORY BASIS FOR THE SENSORY BASIS.	SEE 2.2.
2.5 SENSORY, TRANSDUCERS	PAR. 4.3.3.1			SENSORY REACTION REQUIREMENT SHOULD BE PROVIDED FOR SENSORY- REPLACE IN THE BASIS ON SENSORY BASIS FOR ONE AND TO REPLACE AND CASE.	20-475-50	REQUIREMENTS AND SENSORY BASIS REQUIREMENTS TO SENSORY BASIS TO BE SENSORY BASIS AND SENSORY OF THE BASIS AND SENSORY BASIS.	SEE 2.2.
3.0 SENSORY BASIS 3.3 TRANSDUCERS FOR REPLACEMENT	PAR. 7.4			REQUIRE A BASIS ON ALL SENSORY BASIS OF REACTION AND TRANSDUCERS REQUIRE IN WHICH REQUIREMENT MAY BE REQUIRED ON REQUIREMENT.	20-475-50	A BASIS BASIS SHOULD BE REQUIREMENT FOR THE BASIS BASIS BASIS.	SEE 2.2. SENSORY BASIS FOR A OTHER BASIS.

2.0 SYNOPSIS

HUMAN FACTORS		DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS
		CONSTRUCTION	TECH. REF.		PARTICIPATION	RECOMMENDATIONS		
3.4. PREVENTION FROM FALLING	POL. 7.4			REPORT AND TIME OF JUMP OR CLIMB WITH THE CHAINS OF CABLES.	IN 7.1.1.3	THE REPORT FOR THE JUMP APPROXIMATELY 1000 TO 1200 TO THE JUMP OF JUMPING.	1	IN 7.1.1.
3.5. SAFETY DEVICES (CABLE)	POL. 7.5			THE SAFETY DEVICES OR OTHER FALLING DEVICES TO PREVENT FALLING. MOVEMENT.		A JUMP SHOULD BE PERFORMED IN THE JUMPING OF THE CABLES. SAFETY DEVICES.	1	IN 7.1.1.
	POL. 7.2			THE OPERATION OF SAFETY DEVICES SHOULD BE TESTED BEFORE OPERATIONS SHOULD START. THE FIRST OPERATION OF A RELATED OR A JUMPING CABLE.	IN 7.1.1.3	THE JUMPING SHOULD BE TESTED OF THE JUMP APPROXIMATELY 1000 TO 1200 TO THE JUMPING CABLES. SAFETY DEVICES SHOULD BE TESTED BEFORE OPERATIONS SHOULD START. THE FIRST OPERATION OF A RELATED OR A JUMPING CABLE.	1	IN 7.1.1.

TITLE: NAB NOTE		DOCUMENT COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS
HUMAN FACTORS	UNCLASSIFIED	COMPLIANCE	TECH REF:		PARTICIPATION	RECOMMENDATIONS		
3.5 SAFETY DEFENSE (CONT'D) CONT'D						Scuba - DIVER GEAR Scuba - DIVER GEAR Scuba - DIVER GEAR Scuba - DIVER GEAR Scuba - DIVER GEAR Scuba - DIVER GEAR Scuba - DIVER GEAR		
3.6 WEATHER DEFENSE	POL. 7.1	AMN 803.1-193		EMERGENCY THAT COMPLETION PLANNING ARE REQUIRED FOR COASTING POTENTIALLY EXPOSURE TO THE WEATHER.	20-476-000	THE AREA LOCATED AS THE CENTERS SHOULD BE MARKED AND TO IMPROVE A SAFETY DEFENSE.	2	

2.0 SYNOPSIS

3.0 DISCUSSION

The Human Factors recommendations for the Main Drive are concerned with provisions for safe and efficient maintenance of the system components. Most of these tasks had not been evaluated as yet at the time of the preparation of this report.

One deficiency in the Main Drive design is the failure to provide an electric jacking motor for use as an auxiliary means of activating the launcher platform. This motor would have been used for two functions:

- a. Activation of the launcher platform prior to the connection of the hydraulic system during installation.
- b. Activation of the launcher platform in the event of a hydraulic failure. Access to the hydraulic motor and replacement will be difficult if a hydraulic failure occurs with the platform in the fully elevated position.

The addition of an electric jacking motor was proposed on an ECP to the Air Force but was rejected.

4.0 REFERENCES

1. AFEM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. ASA Z53.1-1953, Safety Color Code for Marking Physical Hazards and the Identification of Certain Equipment.
3. AMF Report ER-TPS-#280, Field Evaluation, 5/4/60.
4. AMF Report ER-TPS-215, Launcher Drive Mechanism Cranking Provisions, June 2, 1959.
5. AMF Report MR-TPS-220, Jacking Motor - Cranking Provisions for the Main Platform Drive, 9/31/59.
6. AMF Document, TS 7.2.23, DDL Review, 12/18/59.
7. AMF Drawing HF-T-1065, Upper Silo Access Layout.
8. AMF Drawing No. HF-T-1034, Catwalk, Emergency Ladder (Quad. IV) to Bridge (Crib-to-Silo) OB.
9. AMF Drawing No. HF-T-1037, Access, Top of Silo (Quad. IV) TF & OB.
10. AMF Drawing No. HF-T-1042, Emergency Catwalk & Ladder Face C & D - OB.
11. AMF Drawing No. HF-T-1051, Platform, Access Cw't Support.

12. AMF Drawing No. HF-T-1052 - Counter-Weight Support Access Layout.
13. AMF Drawing No. HF-T-1055 - Platforms, Silo Upper Access.
14. AMF Drawing No. HF-T-1072 - Alternate Upper Silo Access Layout, OSTF.
15. AMF Drawing No. HF-T-1073 - Access Ladders and Work Platform #1 to Drive Base. TF & OB.
16. AMF Drawing No. HF-T-1076 - Upper Silo Access Layout, TF.
17. AMF Drawing No. HF-T-1090 - Stairway Study Elev. 380' to 392'.
18. AMF Drawing No. HF-T-1102 - Bridge Study Wire Rope Replacement.
19. AMF Drawing No. HF-T-1133 - Method for Replacement of Power Drive Motor (OSTF & TB).
20. AMF Drawing No. HF-T-1134 - Method for Replacement of Power Drive Motor (OSTF & TB).
21. AMF Drawing No. HF-T-1139 - Counterweight Show Replacement Study, TF & OB.
22. AMF Drawing No. HF-T-1146 - Spare Drive Motor Study.

Chapter 22

Human Factors Review and Evaluation
of the
Motor Control Center

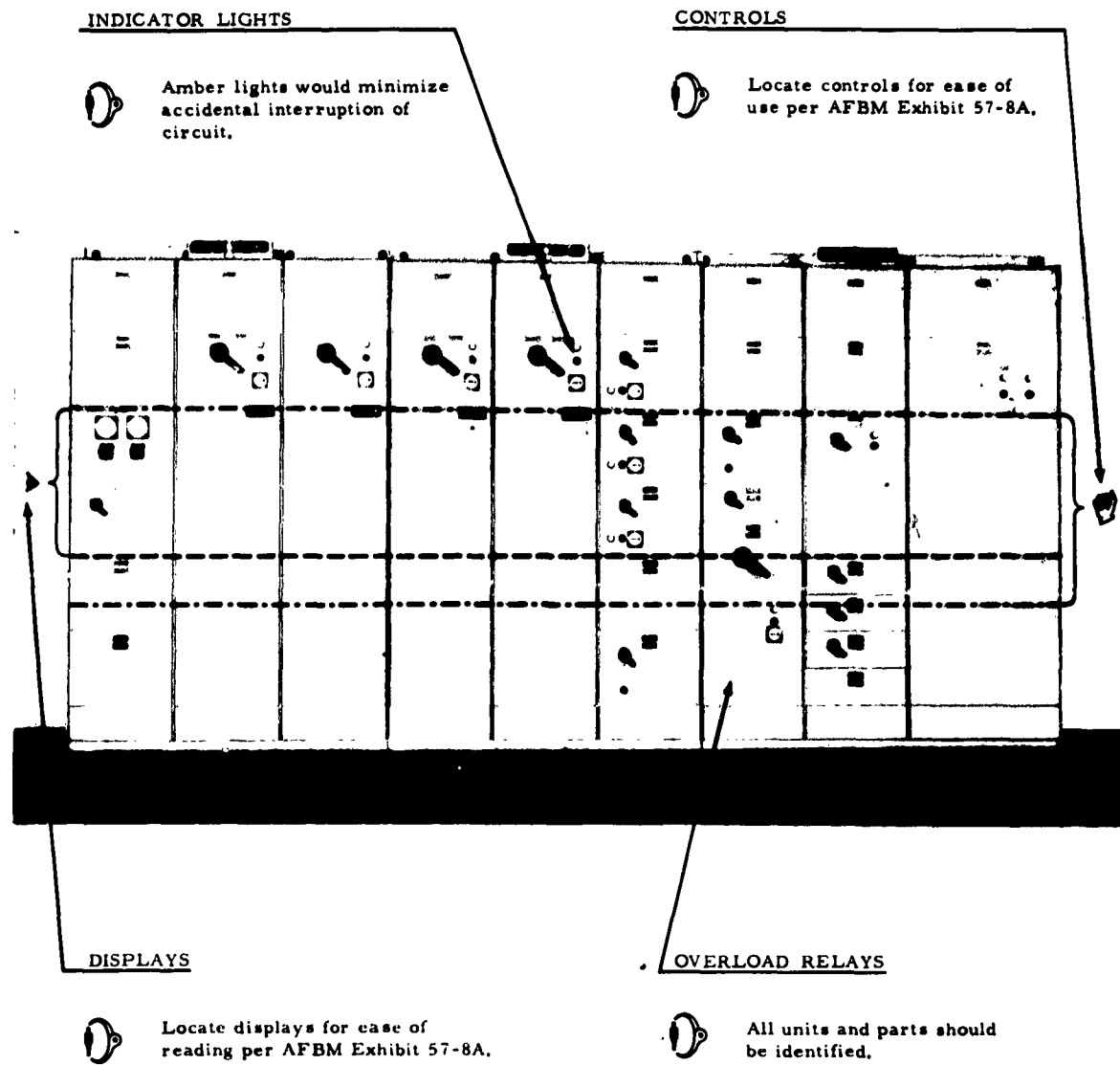


FIGURE 22-1
HUMAN FACTORS INPUTS
MOTOR CONTROL CENTER

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: THE MOTOR CONTROL CENTER										
	Human Factor Effort Required	PHASE IN STAGE				HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	Product Improvement	OSTF TF OB	
SYMBOL										
1.0 HUMAN ENGINEERING DESIGN FACTORS										
1.1 Anthropometric Compatability_____	*			*				*	*	
1.2 Controls and Displays_____	*			*				*	*	
1.3 Fail-Safe Design_____	*			*	*			*	*	
1.4 Malfunction Detection_____								*	*	
2.0 MAINTENANCE FACTORS										
2.1 Access, Visual_____										
2.2 Access, Servicing_____										
2.3 Remove and Replace_____	*	*		*				*	*	
2.4 Handling, Physical Limitations_____	*	*		*				*	*	
2.5 Handling, Transportation_____	*	*		*				*	*	
2.6 Vehicle Maneuverability_____								*	*	
3.0 SAFETY FACTORS										
3.1 Chemical Decontamination_____										
3.2 Escape Provisions_____										
3.3 Protection from Entanglement_____										
3.4 Protection from Falling_____										
3.5 Safety Devices (other)_____	*	*	*	*	*			*	*	
3.6 Warning Devices_____	*	*		*	*			*	*	
4.0 PHYSIOLOGICAL FACTORS										
4.1 Biological Damage_____										
4.2 Vertigo_____										
4.3 Vibration Effects_____										
5.0 PSYCHOLOGICAL FACTORS										
5.1 Fear of Heights_____										
5.2 Fear of Being Crushed_____										
5.3 Fear of Falling_____										
5.4 Fear of Isolation_____										
5.5 Feeling of Insecurity_____										
6.0 ENVIRONMENTAL FACTORS										
6.1 Acoustic Energy (noise)_____										
6.2 Humidity & Temperature_____										
6.3 Illumination_____										
7.0 HUMAN USE FACTORS										
7.1 Procedure_____										
7.2 Time Study_____										
7.3 Training/Selection_____										

FIGURE 22-2

1.0 DESCRIPTION

1.1 In this chapter, the human factors will be considered which are pertinent to the design and installation of the Motor Control Center.

The Motor Control Center conducts, transforms, rectifies and distributes electrical energy to supply the various needs of the Launcher System. Power is provided by others on a 3 phase, 480 volt, 60 cycle main bus. At this interface the Motor Control Center proceeds through its sub systems to distribute power as follows:

- a) 480 volt, 3 phase, 60 cycle to hydraulic supply pump motors through circuit breakers and starters.
- b) 120 volt, 60 cycle to motor starter control circuits and auxiliary uses through transformers and circuit breakers.
- c) 28 volt DC to logic control circuitry through either one of two DC power supplies. Each power supply is individually fused to isolate it from the main supply in the event of malfunction. Automatic switching is provided on the output of the two 28 volt DC power supplies to transfer the DC load from the normal supply to the alternate supply in the event of failure of the normal unit.
- d) 3 volt DC to test circuitry within the Logic System through a 3 volt DC Power Supply.

Three levels of protection are provided to the equipment receiving energy from this control center. Heater coils protect motor windings, overload relays protect circuitry, and circuit breakers protect the electrical system from the destructive burning effects of high current flow.

The actual hardware which comprises the Motor Control Center consists

of components such as circuit breakers, starters, transformers, rectifiers, buses and metering devices arranged within vertical racks completely enclosed on back and sides. Front door panels provide access to the various chassis and all cables and buses enter through the top. The entire unit is located within the Electrical Power and Control Room on the fourth level of the Equipment Terminal Silo.

- 1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate the Motor Control Center efficiently without causing damage to equipment or injury to personnel. The equipment racks must be designed to provide adequate access to heater coils, overload relays and other parts requiring constant service, and where maintenance tasks require removal of components heavier than a man can safely lift special handling devices must be provided. Factors contributing to the successful use of the Motor Control Center have been itemized on the Summary Checklist (Fig. 22-2), and the progress of the Motor Control design has been tabulated in detail in the following Synopsis.

ITEM: <u>WORLD COMBAT CENTER (CONCEPT)</u>																						
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS	RELATIVE VALUE														
	CONTRACTUAL AFPM 52-4A	TECH. REF.		PARTICIPATION	RECOMMENDATIONS																	
2.0 <u>MAINTENANCE FACTORS</u>		PAR. 4.3.3.1	COMPONENT WEIGHTS: KEEP REMOVABLE WEIGHTS BELOW 35 LBS. FOR HANDLING AND CARRYING BY ONE MAN. INCREASE WEIGHT OF ALL COMPONENTS OVER 35 LBS. PROVIDE SPECIAL HANDLING EQUIPMENT FOR ITEMS ABOVE THE FOLLOWING LIMITS: <table><tr><td><u>MAX. WEIGHT</u></td><td><u>MAX. HEIGHT</u></td></tr><tr><td>145</td><td>1 FOOT</td></tr><tr><td>130</td><td>2</td></tr><tr><td>77</td><td>3</td></tr><tr><td>55</td><td>4</td></tr><tr><td>34</td><td>5</td></tr><tr><td>20</td><td>6</td></tr></table>	<u>MAX. WEIGHT</u>	<u>MAX. HEIGHT</u>	145	1 FOOT	130	2	77	3	55	4	34	5	20	6	CRITERIA PRESENTED TO BIDDING GROUP IN CONSIDERATION & BIDDING.				
<u>MAX. WEIGHT</u>	<u>MAX. HEIGHT</u>																					
145	1 FOOT																					
130	2																					
77	3																					
55	4																					
34	5																					
20	6																					
2.3 <u>REMOVE & REPLACE</u>					PROVIDE SPECIAL HANDLING EQUIPMENT (FOR DC POWER SUPPLIES SPECIFICALLY)		NOT ADOPTED	15														
2.4 <u>HANDLING, PHYSICAL LIMITATIONS</u>				COMPONENT WEIGHTS - WEIGHT SPREAD & BIDDING HANDLING IN GROUPS & REPLACE PROCEDURES 25 VDC POWER SUPPLY 21.5 LBS. 3 VDC POWER SUPPLY 9.1 LBS.				5														
2.5 <u>HANDLING, TRANSPORTATION</u>		PAR. 4.3.3.2	HANDLING EQUIPMENT SHALL BE PROVIDED		PROVIDE HANDLING EQUIPMENT AS INDICATED ABOVE			5														
3.0 <u>SAFETY</u>			CIRCUIT BREAKER UNITS SHALL BE PROVIDED WITH SOME METHOD FOR LOCKING IN THE "OFF" POSITION.		PROVIDE CIRCUIT BREAKER UNITS WHICH CAN BE LOCKED IN THE "OFF" POSITION TO PREVENT PERSONNEL WORKING ON LINES AND EQUIPMENT	I I	ADOPTED	20														
3.5 <u>SAFETY DEVICES</u>		PAR. 7.0																				
3.6 <u>WARNING DEVICES</u>		PAR. 7.1	A.3.4.4-435-1 APPENDIX 8 AND 9 EAT. MANUAL OF STANDARDS INSTRUMENTS 8-34		PROVIDE HIGH VOLTAGE SIGNS FOR ALL COMPARTMENTS WHERE THE POTENTIAL EXCEEDS 200 VOLTS		NOT ADOPTED	15														

3.0 DISCUSSION

3.1 Human Factors recommendations have been successfully included in the Motor Control Center:

- a) Where criteria has been provided by the human factors engineers during the early concept stage, and
- b) Where human factors features referenced within the guiding documents (AFEM-57-8A and others) have not been in conflict with the standard manufactured (off-the-shelf) philosophy of the missile program.

3.2 All of the recommendations indicated in the synopsis are still applicable to the Motor Control Center and should be included in the operational bases.

3.3 Where recommendations can not be included without extensive and costly modifications to equipment it is suggested that studies be performed in an effort to improve human factors conditions without involving a change to the existing hardware.

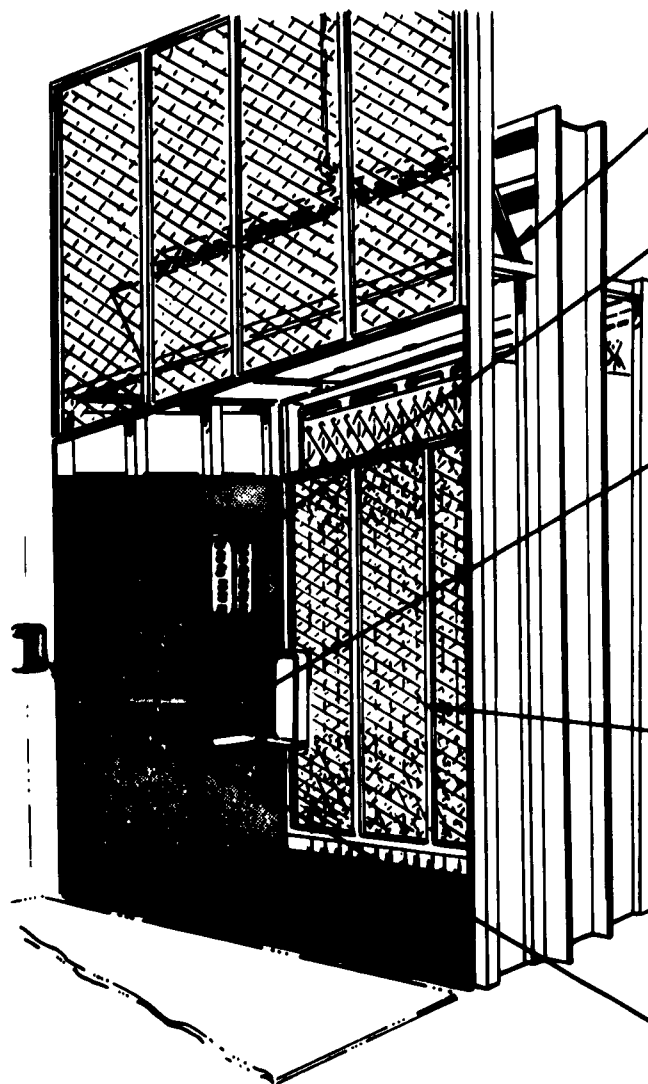
Studies of this nature could bring about improvements as indicated in the following example: The illustration (Fig. 22-1) indicates that many of the controls are above the maximum level for optimum operation as prescribed by the contractual documents. The panels at the bottom of the unit are infrequently used. A light weight removable platform approximately 10 inches in height and running the full length of the control station could be provided which would help bring the controls to within the reach of more of the Air Force population and would not interfere with any of the items mounted on low panel surfaces.

4.0 REFERENCES

1. AFEM Exhibit 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. WADC TR 52-321, Anthropometry of Flying Personnel, 1959.
3. WADC TR 56-171, Layout of Work Places, 1959.
4. ASA Z35.1, Specifications for Industrial Accident Prevention Signs, 10 January 1941, R 1945.
5. U.S. Department of Commerce, National Bureau of Standards Handbook H34, Safety Rules for the Operation of Electrical Equipment and Lines, October 13, 1938.
6. AMF Report, ER-TPS-224, Motor Control Center - Human Factors Review-OSTF, 8/10/59.

Chapter 23

Human Factors Review and Evaluation
of the
Personnel Elevator



ESCAPE METHOD



An escape hatch has been provided in the elevator top.

CONTROL ARRANGEMENT



The control buttons have been arranged for optimum reach, readability, sequence, and priority based upon AFBM 57-8A and documents referenced therein.

TELEPHONE HEIGHT



The telephone has been raised (within design limitations) to improve dial reading and receiver reach.

DOOR OPENINGS



Entrances to the elevator car have been made 78" high to accommodate Air Force personnel in the 95th percentile group.

CAR AND HOISTWAY GATES



Gates have been provided at all entrances to the open hoistway and on the elevator car.



Gates meet A. S. A. design requirements and are electrically interlocked so that elevator cannot move while a gate is open and mechanically locked closed unless the car is available at a level.

CALL BUTTONS



Elevator call buttons have been placed 5' above each level in order to remove them from the path of vehicles and other equipment.



EMERGENCY BRAKE



Excessive dropping speeds are prevented by the use of a fail safe mechanical brake which is tripped when speeds exceed 175 f.p.m.



ADDITIONAL STOP



An additional elevator stop at the silo bottom level would eliminate many problems in emergency rescue operation and maintenance handling now depending upon special rigging procedures.



FIGURE 23-1
HUMAN FACTORS INPUTS
PERSONNEL ELEVATOR

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: PERSONNEL ELEVATOR				Human Factor Effort Required	PHASE IN STAGE	HUMAN FACTORS OBJECTIVE	APPLICABLE ON MODEL		
				Concept Review Analysis Field Input Specification Compliance Safety Operational Status Maintenance Recommendation Product Improvement OSTF TF OB				STAGE	
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1	Anthropometric Compatibility	*	*	*	*	*	*	*	
1.2	Controls and Displays	*	*	*	*	*	*	*	
1.3	Fail-Safe Design	*	*	*	*	*	*	*	
1.4	Malfunction Detection								
2.0 MAINTENANCE FACTORS									
2.1	Access, Visual								
2.2	Access, Servicing	*	*	*	*	*	*	*	
2.3	Remove and Replace								
2.4	Handling, Physical Limitations								
2.5	Handling, Transportation								
2.6	Vehicle Maneuverability								
3.0 SAFETY FACTORS									
3.1	Chemical Decontamination								
3.2	Escape Provisions	*	*	*	*	*	*	*	
3.3	Protection from Entanglement								
3.4	Protection from Falling	*	*	*	*	*	*	*	
3.5	Safety Devices (other)	*	*	*	*	*	*	*	
3.6	Warning Devices	*	*	*	*	*	*	*	
4.0 PHYSIOLOGICAL FACTORS									
4.1	Biological Damage								
4.2	Vertigo								
4.3	Vibration Effects								
5.0 PSYCHOLOGICAL FACTORS									
5.1	Fear of Heights	*	*	*	*	*	*	*	
5.2	Fear of Being Crushed								
5.3	Fear of Falling	*	*	*	*	*	*	*	
5.4	Fear of Isolation	*	*	*	*	*	*	*	
5.5	Feeling of Insecurity								
6.0 ENVIRONMENTAL FACTORS									
6.1	Acoustic Energy (noise)								
6.2	Humidity & Temperature								
6.3	Illumination	*	*	*	*	*	*	*	
7.0 HUMAN USE FACTORS									
7.1	Procedure								
7.2	Time Study								
7.3	Training/Selection								

23-2

1.0 DESCRIPTION

1.1 The Personnel Elevator is the basic means of vertical transportation for men and equipment to the various work platforms in the silo. It has two entrances (6' 3" wide x 6' 6" high) which are opposite each other. One entrance faces the crib and the other faces the access tunnel. The internal dimensions of the elevator are 6' 3" wide x 3' 6" deep x 7' 0" high. Its design is the single wrap traction sheave type and it is drive by an alternating-current electric motor. The elevator has a pushbutton control panel and is capable of stopping within 3/4" of the landing at any of its 8 stops. A hook is provided on the under side of the elevator which permits the attachment of a hoist or use of the elevator itself as a hoist for silo maintenance purposes.

1.2 Applicable Human Factors Considerations

Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to handle the personnel elevator efficiently and safely. The elevator must be able to accept transporting vehicles (i.e. skids, dollys, etc.) and their loads, but is not required to take the Tug Truck or towing vehicle. Other considerations that contribute to the successful operation of the personnel elevator have been itemized on the summary checklist (Fig. 23-2) and tabulated in detail in the following synopsis.

ITEM: PERSONNEL RESPONSE									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	5
	CONSTRUCTION	TECH REF		PARTICIPATION	RECOMMENDATIONS	ANALYSIS	EQUIPMENT TEST		
1.0 BROAD BACKGROUND DESIGN	PAL 6.1.1.1		THE HIGHEST OVERHEAD MOUNTING IS 7'.		OVER SWITCHES ARE 7' HIGH AND THE CEILING IS 8' HIGH.		X	CHECKED IS SATISFIED.	5
1.1 AIRCRAFT/SPACE OPERABILITY	PAL 6.1.1.2		SEATING OPERATOR CONTROLS SHOULD BE NO HIGHER THAN 7'0" AND NO LOWER THAN 3'0".		IT WAS RECOMMENDED THAT THE SEATING CALL BUTTONS BE 5' ABOVE THE PLATFORM LEVEL.		X	RECOMMENDED DISAPPEARED.	5
	PAL 6.1.1.3	WDC 25 56-171	VISUAL DISPLAYS SHOULD BE NO LOWER THAN 4'0" ABOVE THE SEATING SURFACE AND NO FURTHER THAN 20" FROM THE VIEWER'S EYE.	IN ITS OWN	IT WAS RECOMMENDED THAT THE TELEPHONE INSTALLATION BE SAID TO BESET (WITHIN THE SAID LIMITATIONS) TO PROVIDE BETTER NEAR VISIBILITY AND PERSONNEL COMFORT. (SEE 1.2 THIS SUBJECT).		X	THE TELEPHONE WAS SET AS REQUIRED.	5
1.2 CONTROLS AND DISPLAYS	PAL 3.1.1.1	WDC-25 56-171	ALL CONTROLS HAVING SEQUENTIAL RELATION SHALL BE GROUPED TOGETHER. THE SEQUENCES SHOULD BE FROM LEFT TO RIGHT (HORIZONTAL) OR FROM TOP TO BOTTOM (VERTICAL). UNLESS CONTROL/DISPLAY ASSOCIATION IS VIOLATED THE CONTROLS SHOULD BE ALIGNED HORIZONTALLY.	IN ITS OWN	REVIEWER FOR THE SEATING SEATING POSITIONED CONTROL PANEL WAS RECOMMENDED TO ADJUST OTHER ELEMENTS OF ALL CONTROL PANEL COMPONENTS WITHIN THE ALLOTTED SPACE AVAILABLE. IT WAS RECOMMENDED THAT THE CONTROL PANEL BE SEQUENCED FROM A SINGLE VERTICAL ROW OF BUTTONS TO A SINGLE HORIZONTAL ROW OF BUTTONS IMPROVED SIGNIFICANTLY FROM LEFT TO RIGHT (1.1.1.1). THIS WOULD ALLOW THE TELEPHONE TO BE SEQUENCED. IN ALTERNATE RECOMMENDATION WAS A DOUBLE HORIZONTAL ROW NUMBERED 1 THRU 6 IN THE TOP ROW AND 5 THRU 0 IN THE SECOND ROW.		X	THE PANEL WAS RECOMMENDED WITH THE SEATING IN A DOUBLE VERTICAL ROW PER 25-4-100.	5

2.0 SYNOPSIS

ITEM: PASSENGER ELEVATOR					3	3
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RESULTS
	CONTRACTUAL	TECH REF.		PARTICIPATION	RECOMMENDATIONS	
1.2 CONTROLS AND DISPLAYS (CONT'D)	PAL 3.2.1.1.2. 2	MADE TO 56-172 PAL 1.39 (REF. PA)	EMERGENCY STOPPERS SHOULD BE REMOVABLE SHOWN AND 3/4" REMOVABLE RISING.		A TEST AND FINAL RECOMMENDATION WAS MADE AND A LAUNCH INITIATED. THIS LAUNCH SHOWED A DOUBLE REVERSE, NEW OF REVERSE, REVERSE STOP TO BUTTON 1 STOP 4 (LEFT COLUMN) AND 5 STOP 6 (RIGHT COLUMN). ALSO SEEN WAS THE 3/4" REVERSE "STOP" BUTTON REVERSE BUTTON, AN ALARM BELL BUTTON, AND A LINE SWITCH.	
1.3 PASS SAFE BRUSH	PAL 1.4		PHASES OF ANY STOPPERS CONTROLLING BUTTONS OR STOPPERS EQUIPMENT SHOULD NOT BE CAPABLE OF ALLOWING THE ELEVATOR TO FALL FREELY IN THE ELEVATOR SHUT.	IN-774-774	THE ELEVATOR IS EQUIPPED WITH AN ELECTRICALLY RELEASED STOPPER LOADED EMERGENCY BRAKE. THIS BRAKE IS MANUALLY RELEASED BY THE EMERGENCY STOP BUTTON AND AUTOMATICALLY RELEASED BY ENTERING THE EMERGENCY CODEWORD (WHICH TESTS THE BRAKE WHEN THE ELEVATOR SPEED EXCEEDS 175 FPM) ON THE FINAL LIMIT SWITCHES WHICH ARE LOCATED JUST BEFORE THE TERMINAL LANDING. THE ONLY WAY TO RELEASE THE BRAKE ONCE SET IS TO APPLY POWER TO BRAKE ON LEAVE THE CAR. A MANUALLY OPERATED MECHANICAL INTERLOCK IS PROVIDED TO BE USED DURING ELEVATOR MAINTENANCE.	CRITERIA SATISFIED

2.0 SYNOPSIS

ITEM: FERRIS, BLANK									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS		
	CONTRACTUAL APTN 52-3A	TECH REF.		PARTICIPATION	RECOMMENDATIONS			ANAL	BOUP TEST
2.0 MAINTENANCE FACTORS 2.2 ACCESS, SERVICING	6.3.3.9		AREAS OF THE ELEVATOR SUCH AS THE CONTROL PANEL AND DRIVE UNIT WHICH MAY REQUIRE FREQUENT OR SPECIAL SERVICING SHOULD BE EASILY ACCESSIBLE.	6E-106-9117	A REASON FOR AN ACCESS SEIZURE TO THE SIO CONTROL HAS BEEN PERFORMED AT EL. 309 CHAL. ITL. THIS SEIZURE IS IN THE IMMEDIATE VICINITY OF THE ELEVATOR DRIVE UNIT AND WOULD PROVIDE ACCESS. THE CONTROL PANEL ON THE ELEVATOR IS DESIGNED TO KICK OUT AND EXPOSE THE CHANNEL. THE SEIZURE OF THE TOP OF THE ELEVATOR IS ACCESSIBLE THROUGH THE KICK PANEL IN THE CEILING. THE OPERATION OF AN ELEVATOR STOP AT THE BASE OF THE SIO HAS BEEN RECOMMENDED TO IMPROVE MAINTENANCE AND ACCESS TO THAT AREA. ALSO CONSIDERED WAS THE REMOVAL OF TRAINED PERSONNEL FROM THE BASE OF THE SIO.	1	NO IMPROVEMENT.		
					THE OPERATION OF AN ELEVATOR STOP AT THE BASE OF THE SIO HAS BEEN RECOMMENDED TO IMPROVE MAINTENANCE AND ACCESS TO THAT AREA. ALSO CONSIDERED WAS THE REMOVAL OF TRAINED PERSONNEL FROM THE BASE OF THE SIO.	1	SIO WOULD REQUIRE STOP THE SIO. AS ACCESS SEIZURE HAS BEEN PROVIDED FROM ELEVATOR STOP AS TO THE BASE OF THE SIO.		

ITEM: <u>REPAIRS SUBJECT</u>									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	NO
	CONTRACTUAL AFPM 57-54	TECH REF.		PARTICIPATION	RECOMMENDATIONS	ANAL	EQUIP TEST		
3.0 SAFETY 3.0 REPAIR PROVIDERS	7.12	AAA 417.1 BBS 204.15 (IMP. 99)	A. REPAIR PROVIDERS, DISOBTAINED- ORDER OPENING REPAIRMENT KEY WIRE IS PROVIDED. THE BBS OR BATCH SHOULD BE DESIGNED TO OPEN WITH A REMOTE NOTION OF THE BBS ON THE.	BA-775-76	THE REPAIRER HAS A KIDNEY HOLE IN THE CLOTH. IT OPENS WITH AN UPWARD PULL AND IS INTERLOCKED TO THE OPEN POWER TO THE MOTOR. IT WAS DISOBTAINED TO THE OF THE BBS AND INTERLOCK TO THE QUALITY ASSURANCE TEST. A COMPLAINT LAMER IS PROVIDED FOR REPAIRER TO CLAMP THROUGH THE KEY. SINCE THE REPAIR PROVIDER ALSO USED TO ALLOW CLAMPING FOR LAMER ITEMS CLAMPED IN THE REPAIRER THE INTERLOCK SHOULD BE IN PLACE FOR THIS PROVIDER.	I	THE REPAIRER HAS BEEN INCLINED. SINCE INTERLOCK HAS NOT BEEN PROVIDED.	30	
3.1 PROBLEMS FROM FILING	7.8, 7.9	AAA 417.1 BBS 111. BBS 204.1 (IMP. 99)	CAR GATE 1. SHOULD BE 5' HIGH REPAIRER. 2. SHOULD HAVE BEEN WITH 2" REPAIRER WALL REPAIRER. 3. SHOULD BE INTERLOCKED TO REPAIRER REPAIRER OPERATOR WAS NOT COMPLETELY CLAMPED. 4. SHOULD BE INTERLOCKED TO OPEN ONLY WHEN THE REPAIRER IS AT A LAMER. REPAIRER GATE 5. SHOULD COMPLETELY COVER REPAIRER REPAIRER. 6. SHOULD BE INTERLOCKED TO REPAIRER REPAIRER OPERATOR WAS NOT COMPLETELY CLAMPED. 7. SHOULD BE INTERLOCKED TO OPEN ONLY WHEN THE REPAIRER IS STOPPED AT THE LAMER	BA-775-76	THE CAR GATES ARE THE INTERLOCK GATES ARE AUTOMATICALLY INTERLOCKED. THE REPAIRER GATES COMPLETELY COVER THE SAFETY OPENING. THE INITIAL REPAIRER GATE LOCATED AT STOP 1) (ACCESS THROUGH-CHIEF TO STOP REPAIR) WAS SUCH THAT AN OPERATOR HAD TO CLAMP BETWEEN THE GATE AND THE OPEN REPAIRER GATE SHOULD THE CAR BE CALLED AWAY. A RECOMMENDATION FOR A LAMER LAMER BBS IN ALONG THE GATE TO BE CLAMPED FROM THE CAR SHOULD BE INVESTIGATED. ALSO RECOMMENDED WAS THE ADDITION OF A SECOND GATE ON THE REPAIRER SIDE OF THE BRIDGE.	I	THE REPAIRER GATE AT STOP 1) WAS DISOBTAINED AND REMOVED ON THE CHIEF ELIMINATING THE POSSIBILITY OF AN OPERATOR BEING INJURED TO THE OPEN REPAIRER. THE CAR GATE REPAIRER AND REPAIRER AND SAFETY.	30	

ITEM: PERSONNEL BEHAVIOR		DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION	RESULTS
HUMAN FACTORS	CONTRACTUAL AFRM 50-5A	TECH. REF.	PARTICIPATION		RECOMMENDATIONS	ANALYSIS/TEST		
3.4 PROTECTION FROM FALLING (CONT'D)				MEETS THE CASE SCENARIO.		A RECOMMENDATION TO ADD THE CAR CASE BEING EXAMINED AND THE VEHICLE BEING SIZE TO THE ACCEPTANCE TESTS WAS MADE.		
3.5 SAFETY DEVICES		ANSI 2002 (IMP. P.3) ANSI -417.1 (IMP. P.4)		REQUIREMENTS SHOULD BE PROVIDED IN THE ELEVATOR CAR.	BS-175-700A	REQUIREMENTS 1/4" FROM THE FLOOR SHOULD BE PROVIDED AND MONITORED SO AS NOT TO INTERFERE WITH THE CONTROL PANEL OR TELEPHONE.	X	A HALL HAS BEEN PROVIDED ON ONE SIDE ONLY (OPPOSITE CONTROL PANEL) WHICH BONES NOT CONFORM TO ASA SPECIFICATIONS
	7.2			AN EMERGENCY SITUATION REQUIRES FAST POSITIVE ACTION.	BS-1-1001	RECORD OF CONTROLS LAUNCH W/REQUIREMENT STOP SYSTEM AND PLANE LEVEL SYSTEMS IN VERTICAL ORIGIN.	X	INTERLOCKED - OTHER DEVICES RELAYED/STOP SYSTEMS AND CONTROLS.
3.6 WARNING DEVICES				AN INDICATOR WARNING DEVICES COVERS HAVE GENERAL COVERAGE WITH THIS TYPE OF EQUIPMENT. LOCATION AND SIZE OF CAPACITY BEFORE SIGN.		REQUIRE AT THE ESCAPE BRACE TO SHUT OFF POWER IF BRACE IS LIFTED - BUT SHOULD BE OF THE IMMEDIATE TYPE AS THIS BRACE IS ALSO USED FOR OPERATING EQUIPMENT.	X	A FIXED CHAIR INTERRUPTS THAT THE SAFETY SWITCH THEREFORE HAS NOT BEEN PROVIDED.
	7.17					A WARNING BELL TO CALL ATTENTION TO THE ELEVATOR WHEN IN OPERATION. INDICATES THE WEIGHT CAPACITY TO HELP PREVENT OVERLOADING.	X	INTERLOCKED.
5.0 PERFORMANCE FACTORS								
5.1 FEAR OF HEIGHTS					BS-475-10	OPENS SCHEDULED TO REDUCE FEAR OF HEIGHT TOP, STOPS, AND 1/4" OF CASE.	X	NO OTHER MATERIAL HAS BEEN INDICATED ON THE CASE.

ITEM: FIBERGLASS INSULATION									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE CONTRACTUAL AFIRM 52-44	TECH. REF.	CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	AFIRM 52-44
				PARTICIPATION	RECOMMENDATIONS	ANALYSIS	TEST		
5.3 FEAR OF FALLING				88-078-78	SEE ABOVE (S.1)			SEE ABOVE.	
5.4 FEAR OF ISOLATION	SEE CHAPTER 6 SECTION 5.1.		SEE CHAPTER 6, SECTION 5.1.	SEE CHAPTER 6, SECTION 5.1.	TELEPHONE ISOLATED TO PREVENT ISOLATION BETWEEN FLOORS DUE TO POWER FAILURE.			ISOLATED.	
6.0 ENVIRONMENTAL FACTORS									
6.3 TELEVISION	7.23	879-8008	ALL HOME AREAS SHOULD BE EQUIPPED WITH AT LEAST 25 FOOT CABLES.		LOCATING FIBERS WILL BE FULLY RECORDED IN THE CATALOG OF RECORDS.			ISOLATED.	

2.0 SYNOPSIS

3.0 DISCUSSION

- 3.1 The Personnel Elevator should be improved by considering the following modifications in the design. The load capacity should be increased so that more equipment and personnel can be transported without approaching the limit of rated capacity. If the Personnel Elevator could be provided with a stop at the bottom (e.g. elevation 255'-4") many of the present handling problems in the lower silo area would have been simplified. By having the elevator stop at the grating elevation, injured personnel as well as heavy components could be handled more easily without special equipment brought in for the emergency. The method of escape from the Personnel Elevator leaves the personnel involved in a precarious position on top of the elevator. A safe escape method from the elevator top should be provided, otherwise personnel will be in greater danger should they use such a limited escape procedure.
- 3.2 These Human Factors recommendations apply to the training and operational bases as they now exist, and should apply to future design specifications for Personnel Elevators in any system.

4.0 REFERENCES

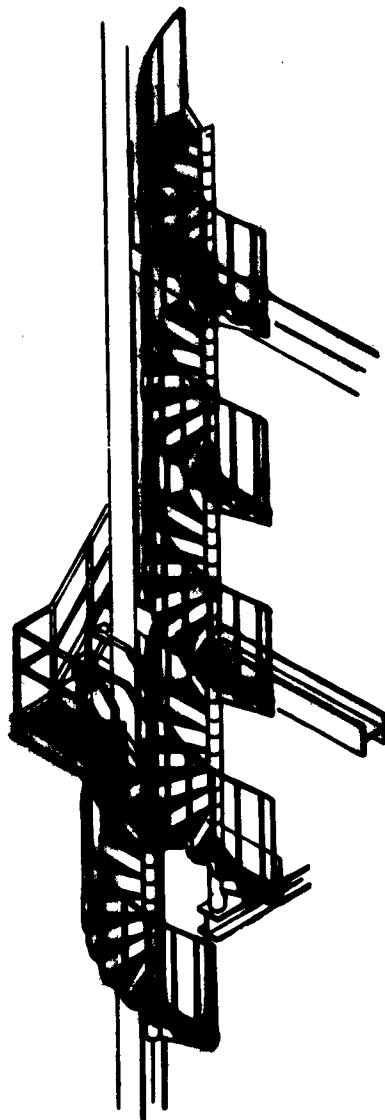
1. AFBM 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. WADC TR 56-171, Layout of Workplaces, Chapter V of the Joint Services Human Engineering Guide to Equipment Design.
3. ASA A17.1, American Standards Safety Code for Elevators.
4. ADS 2002A, Personnel Elevator for WS 107A-2 Launcher System.
5. APS-2002A, Personnel Elevator for WS 107A-2 Launcher System.
6. AMF Procurement Specification - 2302, 1/18/60.
7. AMF Report, ER-TPS-204, Evaluation of Personnel Elevator for WS 107A-2 Launcher System for TB & OB, 4/17/59.
8. AMF Report, ER-TPS-78, Personnel Elevator - Human Factors Requirements, 7/14/58.
9. AMF Drawing No. SK-194-91137, Emergency Ladder-W.P. #3 to Top of Silo, Quad, III, Face "C".
10. AMF Drawing No. HF-T-1001, Personnel Elevator Controls (Recommended Arrangement).
11. AMF Drawing No. HF-T-1032, Clearance Between Sheave and Hand Rail.
12. AMF Drawing No. HF-T-1077, Personnel Elevator Envelope Study for TF & OB.
13. AMF Drawing No. HF-T-1130, Personnel Elevator Call Button Locations.

14. AMF Drawing No. HF-T-1145, Personnel Elevator Controls & Telephone Envelope.

15. AMF Drawing No. HF-T-1151, Elevator Call Button - OSTF Tunnel Entrance.

Chapter 24

Human Factors Review and Evaluation
of the
Safety Equipment



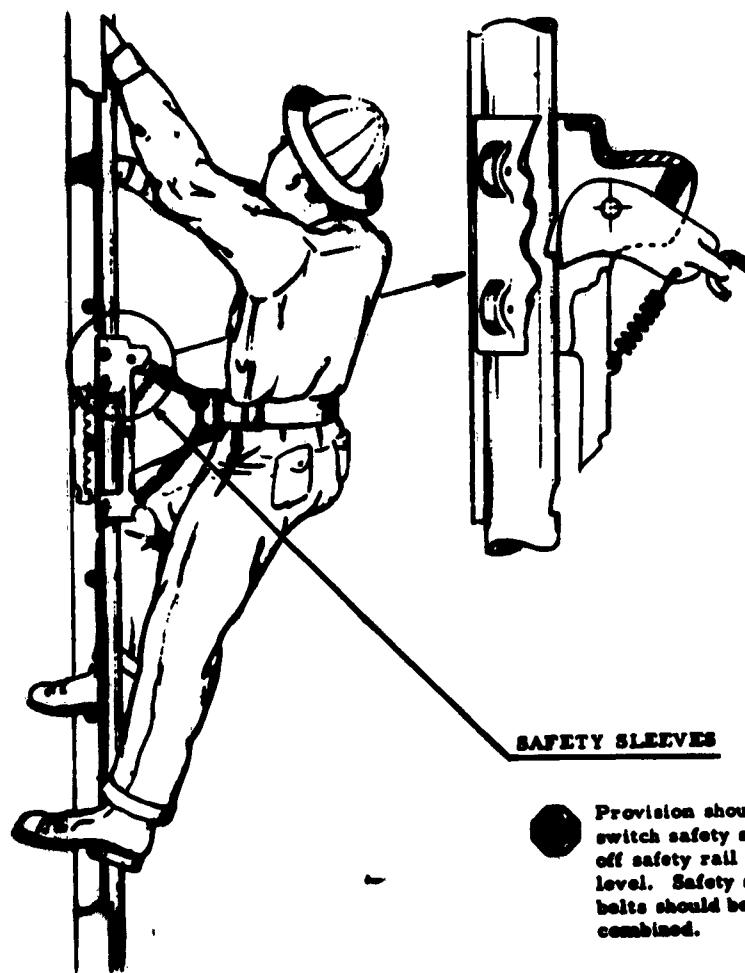
TRAINING ACCESS



The personnel stairway provides easy access to work platform levels during training procedures.

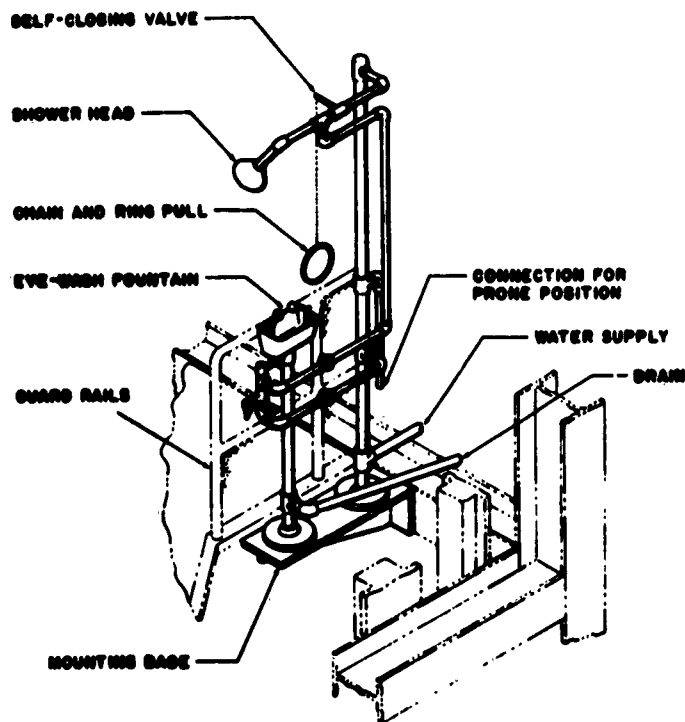


FIGURE 24-1
HUMAN FACTORS INPUTS
PERSONNEL STAIRWAY



Provision should be made to switch safety sleeves on or off safety rail at any platform level. Safety sleeves and belts should be permanently combined.

FIGURE 24-2
HUMAN FACTORS INPUTS
EMERGENCY LADDER
SAFETY RAIL & SLEEVE



ORIENTATION



Emergency shower and eye-wash stations should be identically located on each work platform level.



FIGURE 24-3
HUMAN FACTORS INPUTS
SHOWER AND EYEWASH
STATIONS

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: PERSONNEL STAIRWAY									
	Human Factor Effort Required	PHASE IN STAGE			HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
		Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	OSTF	TF
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability	*	*	*	*	*	*	*	*	*
1.2 Controls and Displays									
1.3 Fail-Safe Design									
1.4 Malfunction Detection									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual	*	*	*	*	*	*	*	*	*
2.2 Access, Servicing	*	*	*	*	*	*	*	*	*
2.3 Remove and Replace									
2.4 Handling, Physical Limitations									
2.5 Handling, Transportation									
2.6 Vehicle Maneuverability									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination	*	*	*	*	*	*	*	*	*
3.2 Escape Provisions	*	*	*	*	*	*	*	*	*
3.3 Protection from Entanglement									
3.4 Protection from Falling	*	*	*	*	*	*	*	*	*
3.5 Safety Devices (other)									
3.6 Warning Devices									
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling	*	*	*	*	*	*	*	*	*
5.4 Fear of Isolation									
5.5 Feeling of Insecurity	*	*	*	*	*	*	*	*	*
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature									
6.3 Illumination									
7.0 HUMAN USE FACTORS									
7.1 Procedure	*	*	*	*	*	*	*	*	*
7.2 Time Study									
7.3 Training/Selection	*	*	*	*	*	*	*	*	*

FIGURE 24-4
SAFETY EQUIPMENT

**SUMMARY CHECKLIST OF
HUMAN FACTORS PROGRAM
IN RELATION TO:
BOTTOM ACCESS STAIRWAY**

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: BOTTOM ACCESS STAIRWAY										Human Factor Effort Required		PHASE IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL		SYMBOL			
										Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	Product Improvement	OSTF		TF	OB	
1.0 HUMAN ENGINEERING DESIGN FACTORS																					
1.1	Anthropometric Compatability_____									*		*	*	*	*	*	*	*	*	*	
1.2	Controls and Displays_____																				
1.3	Fail-Safe Design_____																				
1.4	Malfunction Detection_____																				
2.0 MAINTENANCE FACTORS																					
2.1	Access, Visual_____									*		*	*	*	*	*	*	*	*		
2.2	Access, Servicing_____									*		*	*	*	*	*	*	*	*		
2.3	Remove and Replace_____									*		*	*	*	*	*	*	*	*		
2.4	Handling, Physical Limitations_____									*		*	*	*	*	*	*	*	*		
2.5	Handling, Transportation_____									*				*	*	*	*	*	*		
2.6	Vehicle Maneuverability_____																				
3.0 SAFETY FACTORS																					
3.1	Chemical Decontamination_____																				
3.2	Escape Provisions_____									*		*	*	*	*	*	*	*	*		
3.3	Protection from Entanglement_____																				
3.4	Protection from Falling_____									*		*	*	*	*	*	*	*	*		
3.5	Safety Devices (other)_____																				
3.6	Warning Devices_____																				
4.0 PHYSIOLOGICAL FACTORS																					
4.1	Biological Damage_____																				
4.2	Vertigo_____																				
4.3	Vibration Effects_____																				
5.0 PSYCHOLOGICAL FACTORS																					
5.1	Fear of Heights_____																				
5.2	Fear of Being Crushed_____																				
5.3	Fear of Falling_____									*		*	*	*	*	*	*	*	*		
5.4	Fear of Isolation_____																				
5.5	Feeling of Insecurity_____									*		*	*	*	*	*	*	*	*		
6.0 ENVIRONMENTAL FACTORS																					
6.1	Acoustic Energy (noise)_____																				
6.2	Humidity & Temperature_____																				
6.3	Illumination_____																				
7.0 HUMAN USE FACTORS																					
7.1	Procedure_____																				
7.2	Time Study_____																				
7.3	Training/Selection_____																				

FIGURE 24-5
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: EMERGENCY LADDER										
	Human Factor Effort Required			PHASE IN STAGE		HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	
	Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	Product Improvement	OSTF TF	OB	
1.0 HUMAN ENGINEERING DESIGN FACTORS										
1.1 Anthropometric Compatability_____	*	*	*	*	*			*	*	*
1.2 Controls and Displays_____										
1.3 Fail-Safe Design_____										
1.4 Malfunction Detection_____										
2.0 MAINTENANCE FACTORS										
2.1 Access, Visual_____										
2.2 Access, Servicing_____										
2.3 Remove and Replace_____										
2.4 Handling, Physical Limitations_____										
2.5 Handling, Transportation_____										
2.6 Vehicle Maneuverability_____										
3.0 SAFETY FACTORS										
3.1 Chemical Decontamination_____										
3.2 Escape Provisions_____	*	*		*	*			*	*	*
3.3 Protection from Entanglement_____										
3.4 Protection from Falling_____	*	*								
3.5 Safety Devices (other)_____	*	*		*	*			*	*	*
3.6 Warning Devices_____				*				*	*	*
4.0 PHYSIOLOGICAL FACTORS										
4.1 Biological Damage_____										
4.2 Vertigo_____										
4.3 Vibration Effects_____										
5.0 PSYCHOLOGICAL FACTORS										
5.1 Fear of Heights_____										
5.2 Fear of Being Crushed_____										
5.3 Fear of Falling_____	*	*		*	*			*	*	*
5.4 Fear of Isolation_____	*	*						*	*	*
5.5 Feeling of Insecurity_____	*	*		*				*	*	*
6.0 ENVIRONMENTAL FACTORS										
6.1 Acoustic Energy (noise)_____										
6.2 Humidity & Temperature_____										
6.3 Illumination_____										
7.0 HUMAN USE FACTORS										
7.1 Procedure_____										
7.2 Time Study_____										
7.3 Training/Selection_____										

FIGURE 24-6
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: GUARD RAILS AND SAFETY GATES									

FIGURE 24-7
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: SAFETY NETS											
	Human Factor Effort Required				PHASE IN STAGE		HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL	SYMBOL
	Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation Product Improvement	OSTF	TF	OB			
1.0 HUMAN ENGINEERING DESIGN FACTORS											
1.1 Anthropometric Compatability_____	*	*	*	*	*			*	*	*	
1.2 Controls and Displays_____											
1.3 Fail-Safe Design_____											
1.4 Malfunction Detection_____											
2.0 MAINTENANCE FACTORS											
2.1 Access, Visual_____											
2.2 Access, Servicing_____											
2.3 Remove and Replace_____											
2.4 Handling, Physical Limitations_____											
2.5 Handling, Transportation_____											
2.6 Vehicle Maneuverability_____											
3.0 SAFETY FACTORS											
3.1 Chemical Decontamination_____											
3.2 Escape Provisions_____											
3.3 Protection from Entanglement_____											
3.4 Protection from Falling_____	*	*	*	*	*	*	*	*	*	*	
3.5 Safety Devices (other)_____											
3.6 Warning Devices_____											
4.0 PHYSIOLOGICAL FACTORS											
4.1 Biological Damage_____											
4.2 Vertigo_____											
4.3 Vibration Effects_____											
5.0 PSYCHOLOGICAL FACTORS											
5.1 Fear of Heights_____											
5.2 Fear of Being Crushed_____											
5.3 Fear of Falling_____	*	*	*	*	*	*	*	*	*	*	
5.4 Fear of Isolation_____											
5.5 Feeling of Insecurity_____	*	*	*	*	*	*	*	*	*	*	
6.0 ENVIRONMENTAL FACTORS											
6.1 Acoustic Energy (noise)_____											
6.2 Humidity & Temperature_____											
6.3 Illumination_____											
7.0 HUMAN USE FACTORS											
7.1 Procedure_____											
7.2 Time Study_____											
7.3 Training/Selection_____											

FIGURE 24-8
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: MAIN CLOSURE DOOR KLAXON									
	Human Factor Effort Required				PHASE IN STAGE	HUMAN FACTORS OBJECTIVE			APPLICABLE ON MODEL
	Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status Maintenance Recommendation Product Improvement	OSTF	TF	OB	SYMBOL
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability_____									
1.2 Controls and Displays_____									
1.3 Fail-Safe Design_____									
1.4 Malfunction Detection_____									
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual_____									
2.2 Access, Servicing_____									
2.3 Remove and Replace_____									
2.4 Handling, Physical Limitations_____									
2.5 Handling, Transportation_____									
2.6 Vehicle Maneuverability_____									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination_____									
3.2 Escape Provisions_____									
3.3 Protection from Entanglement_____									
3.4 Protection from Falling_____									
3.5 Safety Devices (other)_____									
3.6 Warning Devices_____	*	*			*	*	*	*	
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage_____									
4.2 Vertigo_____									
4.3 Vibration Effects_____									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights_____									
5.2 Fear of Being Crushed_____	*	*			*	*	*	*	
5.3 Fear of Falling_____									
5.4 Fear of Isolation_____									
5.5 Feeling of Insecurity_____									
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)_____									
6.2 Humidity & Temperature_____									
6.3 Illumination_____									
7.0 HUMAN USE FACTORS									
7.1 Procedure_____									
7.2 Time Study_____									
7.3 Training/Selection_____									

FIGURE 24-9
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: CONTAMINATION SAFEGUARDS Preventive Procedures:													
	Human Factor Effort Required				PHASE IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL				
	Concept	Review	Analysis	Field Input	Specification	Safety	Operational Compliance	Maintenance Status	Product Recommendation	OSTF	TF	OB	SYMBOL
1. Selection of Chemical Materials													
2. Use of Protective Equipment													
3. Proper Handling of Materials													
1.0 HUMAN ENGINEERING DESIGN FACTORS													
1.1	Anthropometric Compatability												
1.2	Controls and Displays												
1.3	Fail-Safe Design												
1.4	*	*		*	*	*	*	*	*	*	*		
2.0 MAINTENANCE FACTORS													
2.1	Access, Visual												
2.2	*	*		*	*	*	*	*	*	*	*		
2.3	*	*		*	*	*	*	*	*	*	*		
2.4	Handling, Physical Limitations												
2.5	Handling, Transportation												
2.6	Vehicle Maneuverability												
3.0 SAFETY FACTORS													
3.1	Chemical Decontamination												
3.2	Escape Provisions												
3.3	Protection from Entanglement												
3.4	Protection from Falling												
3.5	*	*		*	*	*	*	*	*	*	*		
3.6	*	*		*	*	*	*	*	*	*	*		
4.0 PHYSIOLOGICAL FACTORS													
4.1	*	*		*	*	*	*	*	*	*	*		
4.2	Vertigo												
4.3	Vibration Effects												
5.0 PSYCHOLOGICAL FACTORS													
5.1	Fear of Heights												
5.2	Fear of Being Crushed												
5.3	Fear of Falling												
5.4	Fear of Isolation												
5.5	*	*		*	*	*	*	*	*	*	*		
6.0 ENVIRONMENTAL FACTORS													
6.1	Acoustic Energy (noise)												
6.2	Humidity & Temperature												
6.3	Illumination												
7.0 HUMAN USE FACTORS													
7.1	*	*		*	*	*	*	*	*	*	*		
7.2	Time Study												
7.3	*	*		*	*	*	*	*	*	*	*		

FIGURE 24-10
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: CONTAMINATION SAFEGUARDS Protective Procedures:										PHASE IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL							
Shower and Eyewash Stations										Human Factor Effort Required											
										Concept Review	Analysis	Field Input	Specification Compliance	Operational Status	Maintenance Recommendation	Product Improvement	OSTF	TF	OB	SYMBOL	
1.0 HUMAN ENGINEERING DESIGN FACTORS																					
1.1	Anthropometric Compatability									*	*			*	*		*	*	*		
1.2	Controls and Displays									*	*			*	*		*	*	*		
1.3	Fail-Safe Design																				
1.4	Malfunction Detection																				
2.0 MAINTENANCE FACTORS																					
2.1	Access, Visual																				
2.2	Access, Servicing																				
2.3	Remove and Replace																				
2.4	Handling, Physical Limitations																				
2.5	Handling, Transportation																				
2.6	Vehicle Maneuverability																				
3.0 SAFETY FACTORS																					
3.1	Chemical Decontamination									*	*			*	*		*	*	*		
3.2	Escape Provisions																				
3.3	Protection from Entanglement																				
3.4	Protection from Falling																				
3.5	Safety Devices (other)																				
3.6	Warning Devices																				
4.0 PHYSIOLOGICAL FACTORS																					
4.1	Biological Damage									*	*			*	*		*	*	*		
4.2	Vertigo																				
4.3	Vibration Effects																				
5.0 PSYCHOLOGICAL FACTORS																					
5.1	Fear of Heights																				
5.2	Fear of Being Crushed																				
5.3	Fear of Falling																				
5.4	Fear of Isolation																				
5.5	Feeling of Insecurity									*	*			*			*	*	*		
6.0 ENVIRONMENTAL FACTORS																					
6.1	Acoustic Energy (noise)																				
6.2	Humidity & Temperature																				
6.3	Illumination																				
7.0 HUMAN USE FACTORS																					
7.1	Procedure																				
7.2	Time Study																				
7.3	Training/Selection																				

FIGURE 24-11
SAFETY EQUIPMENT

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: SAFEGUARDS AGAINST HUMAN INITIATED FAILURES:									
	Human Factor Effort Required				PHASE IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL
	Concept Review	Analysis	Field Input	Specification Compliance	Safety	Operational Status	Maintenance Recommendation	Product Improvement	OSTF TF OB
1. Color Coding of Manual Valves									
2. Periodic Revision of Maintenance Procedures									
3. Establishment of Installation Procedures									
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatability	*	*	*	*	*	*	*	*	*
1.2 Controls and Displays	*	*	*	*	*	*	*	*	*
1.3 Fail-Safe Design	*	*	*	*	*	*	*	*	*
1.4 Malfunction Detection	*	*	*	*	*	*	*	*	*
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual	*	*	*	*	*	*	*	*	*
2.2 Access, Servicing	*	*	*	*	*	*	*	*	*
2.3 Remove and Replace	*	*	*	*	*	*	*	*	*
2.4 Handling, Physical Limitations									
2.5 Handling, Transportation									
2.6 Vehicle Maneuverability									
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination									
3.2 Escape Provisions									
3.3 Protection from Entanglement									
3.4 Protection from Falling									
3.5 Safety Devices (other)									
3.6 Warning Devices	*	*	*	*	*	*	*	*	*
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage									
4.2 Vertigo									
4.3 Vibration Effects									
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights									
5.2 Fear of Being Crushed									
5.3 Fear of Falling									
5.4 Fear of Isolation									
5.5 Feeling of Insecurity	*	*	*	*	*	*	*	*	*
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)									
6.2 Humidity & Temperature									
6.3 Illumination									
7.0 HUMAN USE FACTORS									
7.1 Procedure	*	*	*	*	*	*	*	*	*
7.2 Time Study									
7.3 Training/Selection	*	*	*	*	*	*	*	*	*

FIGURE 24-12
SAFETY EQUIPMENT

1.0 DESCRIPTION

1.1.0 The safety equipment presented herein covers only those safety features which have not been treated in previous chapters. These items include:

- a. personnel access ways, such as the personnel stairway, and the bottom access stairway,
- b. personnel safeguards, such as the emergency ladder, guard rails, safety nets, safety gates and audible warning devices,
- c. contamination safeguards, such as protective procedures and equipment to prevent contamination, and decontamination equipment such as the eyewash and shower station for use in case of chemical contamination,
- d. safeguards against human initiated failures, such as the coding of manually operated valves and the periodic revision of maintenance procedures.

1.1.1 Personnel Accessways

a. Personnel Stairway

The personnel stairway is mounted on the crib structure between elevation 307'-5 $\frac{1}{4}$ " and 379'-0", and is attached to the outer face "D" in Quadrant IV. This stairway is used at the Training Facility to provide an additional means for personnel to move from one work platform to another. This is necessary because of the increased traffic demands characteristic of a training base. (Ref. 5 & 6).

b. Bottom Access Stairway

As a result of AMF's Facility Access Studies (Ref. 3 & 4) which revealed that there was no means of obtaining easy access from the

bottom of the crib to the lower $14\frac{1}{2}$ feet of the silo and grating, an additional stairway and platform was added from Elevator Stop No. 8 at Elevation 269'-10" down to the grating of the Silo, at Elevation 255'-4".

1.1.2 Personnel Safeguards

a. Emergency Ladders

An emergency ladder is required to permit personnel to evacuate the Silo in case of emergency without depending on the elevator or personnel stairway (Ref. 12). All fixed ladders of 20 feet or more in height require the additional protection of a cage guard. This enclosure is fastened to the side rails so that it encloses the climbing space of the ladder for the safety of the person who must climb the ladder (Ref. 10). This cage serves to protect personnel from accidental falling, since its narrow size will tend to brace a man who slips, and it also serves to deflect possible falling objects, so that they will not strike personnel using the emergency ladder. Also, the cage protects personnel from swinging hoists or other heavy moving equipment which could possibly swing into an unprotected area. Since the emergency ladder represents a straight drop of over 100 feet and The American Standard Safety Code (Ref. 7 and 11) requires either landing platforms at every 30 feet of height or the use of carrier rails with safety belts, this installation employs the additional safeguard of a carrier (guide) rail which has been attached to the centerline of the rungs. A safety sleeve, which travels along the rail, is attached to the safety belt (Ref. 9).

In normal operation, the safety sleeve is spring loaded to keep the latching device away from the rail, thus permitting personnel to climb up or down the ladder. If, however, anything disabling should occur while one is on the ladder, the weight of the body would override the spring and force the latch into the nearest locking slot of the guide rail (Ref. 8). This device provides valuable protection in several ways. It limits a person's fall to 6 inches if one slips off a rung or is overcome by toxic fumes. In case a person were injured but not rendered unconscious, he could pull himself up the escape ladder by hand, by using the locking characteristic to climb upward. The inclusion of the guide rail and safety sleeve virtually provides personnel with one extra hand. In the worst conceivable circumstance, if a man lost the use of as much as one hand and two feet, nevertheless with the use of only one good hand and the guide rail, he would still be able to pull himself up to the top of the emergency ladder.

b. Safety Nets

At the top of the Silo on the catwalk at 389'-0", Face D, an overhanging structure with safety net was added in order to provide personnel with safe access around the hydraulic manifold, (Ref. 13), as authorized by Preliminary Engineering Inspection RFA #12.

c. Guard Rails

On those occasions when there is no missile in the silo, guard rails are needed adjacent to the missile area along the inner edges of the work platforms, to protect personnel from falling into the open pit (Ref. 15, 16, 17, and 18).

d. Safety Gates

Safety gates are provided at all personnel elevator stops in order to prevent personnel from falling into an open shaft, and to protect them from possible injury which could be caused by moving parts in the elevator travel space (Ref. 1 and 2).

e. Audible Warning Devices

Operation of the main closure doors from the local control station automatically actuates a warning klaxon horn, which sounds continuously throughout the operation of the doors. As an additional safeguard, the audible warning device sounds for 30 seconds before the doors begin to move (Ref. 1).

1.1.3 Contamination Safeguards

Contamination safeguards exist in 2 areas:

- (1) in preventive measures, such as cautious selection of chemical materials, use of protective equipment and the proper handling of materials in order to prevent contamination (Ref. 24),
- (2) and in protective measures, such as the provision of procedures and equipment to be used in order to achieve decontamination in case the preventive measures fail.

a. Selection of Materials: Preventive Safeguards

In order to minimize chemical contamination of personnel, or biological damage from fumes, burns or explosions, great care should be taken in the selection of chemical materials for use in the Silo (Ref. 23).

The most fundamental consideration is the selection of all materials, whether to be used in fabrication or maintenance, on the basis of their compatibility with liquid oxygen (Ref. 21 & 22).

This oxidizer is a very hazardous fluid and is especially incompatible with the hydrocarbons, such as acetylene or grease and dirt, even in minute particle quantities.

Carbon tetrachloride is another highly toxic fluid which should be avoided for cleaning. Other fluids are equally useful and have the added advantage of being safe for area personnel (Ref. 20, and 19).

One other practice which applies universally to the Silo is lubrication. Extreme care should be taken to select and recommend halocarbons for lubricants instead of hydrocarbons.

Another real and insidious hazard is the damage which results from the undetected presence of gaseous nitrogen. If nitrogen escapes from nitrogen lines, being heavier than oxygen, it settles at the bottom of the Silo. If large volumes of nitrogen are permitted to accumulate, personnel who are working in the area and unaware of the presence of this odorless gas or conversely, of the absence of necessary alveolar oxygen, will become asphyxiated and unable even to summon help. To protect personnel from this possibility, either adequate ventilation must be provided at the bottom of the Silo or some visual/auditory means of warning personnel of hazardous levels of toxic fumes must be provided (Ref. 22).

b. Handling of Hazardous Materials: Preventive Safeguards

Hazardous materials such as liquid oxygen, other cryogenic chemicals, or toxic paints and cleaning agents, should be handled only by personnel who are properly equipped with protective clothing and devices. They should always adhere to the prescribed procedures for the safe handling of hazardous materials (Ref. 22).

In addition, in all areas where liquid oxygen compatibility is required, the floors and decks should be provided with non-sparking surfaces, in order to prevent the hazards of fire or explosion (Ref. 21).

Scrupulous cleanliness also is of prime importance. Even microscopic particles of welding materials or hydrocarbonaceous material, such as the ubiquitous granules of grease and dirt, are subject to spontaneous combustion, if liquid oxygen comes in contact with them. It is imperative that a clean environment be maintained, and that personnel be protected from accidental oxidation, an ever present danger in a liquid oxygen environment.

c. Shower and Eyewash Station: Protective Safeguard

The Shower and Eyewash Stations, of which there are a total of 6, are located one at each of the five work platforms, and one at the top of the launcher platform. The shower is activated by pulling an oversized ring on a chain and the eyewash spray is operated by hand. With this type of control, the shower and eyewash should be easy to operate simultaneously under emergency conditions (Ref. 25, 26, 27, 28, 29 and 30).

1.1.4 Safeguards Against Human Initiated Failures

It is most desirable to prevent or at the least to minimize human initiated failures in any weapon system. Considerable attention has been given to this effort on the Titan Launcher System under other related chapters (i.e. No. 19 Logic System and Test Equipment, No. 20 Tunnel Entrance Control Station) where extensive investigation of human failure situations was performed and reported. However, some areas which have not been covered elsewhere and fall within the category of product improvement are mentioned below:

a. Color Coding Manual Valves

At present, there is no way of visually ascertaining the proper operating position of the near hundred manually operated valves in the Titan Launcher System, nor of determining visually if the valves are set at the proper position (Ref. 31). A greatly needed improvement would be the color coding of each valve to indicate the normal operating position: black handles for normally closed valves, yellow handles for normally open valves, and white markers on the handle at the 12 o'clock position when the valve is properly set.

b. Revision of Maintenance Procedures

Although maintenance procedures were established as hardware systems have been developed, changes in hardware design mean that maintenance procedures must be revised and coordinated at an equal pace. However, since these revisions are established in the field, there has been no opportunity to evaluate the

revised procedures from the human factors point-of-view. In order to assure that the best human factors applications are perpetuated on the titan Launcher System, all field revisions should be reviewed by the Human Factors team (Ref. 32).

1.2 Applicable Human Factors Considerations

Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to operate efficiently within the confines of the missile silo without causing damage to equipment or injury to themselves or to other personnel. The areas to be frequented by personnel must provide adequate protection in the way of design, markings, warnings, and supplementary devices if they are required (Ref. 1 and 2). Factors contributing to safe and successful operation by personnel have been itemized on the summary checklists, Figures 24-4, 24-5, 24-6, 24-7, 24-8, 24-9, 24-10, 24-11 and 24-12.

2.0 SYNOPSIS

The synopsis sheets have been deleted from this chapter because each item of safety equipment has already been adequately treated in previous chapters, in Human Factors drawings and in AMF drawings. The complete list of drawings, by subject, are included in Section 4.0 References.

3.0 DISCUSSION

Safety equipment, as such, should instill confidence in the user and provide for any possible eventuality.

3.1 Carrier Rail Safety Sleeves

After the carrier rail was installed, it was suggested by the Human Factors team that the carrier rail should have a break at each work level, as a product improvement. This break would have allowed an individual to switch in and out at each level as needed if the safety sleeve were permanently attached to his safety belt (Ref. 3).

As the system exists now, there are good possibilities that all of the safety sleeves will be found piled up at the top of the ladder. After use, as each successive safety sleeve is left at the top of the rail, the lowest sleeve will be positioned so far below the minimum space required for proper departure, that personnel will be forced to disconnect their safety belts from the safety sleeve while they are perched in their most vulnerable position. Another undesirable possibility exists. Personnel traveling up the ladder during an emergency would be forced to uncouple and couple each successive safety sleeve upon contact as he traveled upward, unless he were able to push them upward ahead of him.

Inevitably, it will be found that as long as the safety sleeves are not attached permanently to the safety belts, they will always be found bunched together at one location, and never at the right level when needed.

3.2 Safety Nets

Whereas the presence of a safety net may encourage a feeling of confidence in personnel working in the upper silo levels, it would be preferable if additional safeguards could be provided. It would be better if falling could be prevented. In the area of the hydraulic manifold at the upper catwalk level, it is virtually impossible for personnel to move around the manifold. A simple yet very effective safeguard is the addition of safety belt hooks at appropriate locations which would permit personnel to attach a safety belt while working or walking in the manifold area. It is recommended that these appropriate locations be "field-designated" at the actual installation.

3.3 Eye Wash and Shower Stations

It is necessary to install Eyewash and Shower Stations at identical locations on each work level so that when they are needed, contaminated personnel will be uniformly oriented wherever they are and need not be confused or delayed by differences in locations.

4.0 REFERENCES

GENERAL

1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile Equipment, 1 November 1958.
2. ADS-1003C, Design Specification for Personnel Safety for WS 107A-2 Launcher System, American Machine & Foundry Company, Greenwich Engineering Division, Revised 29 June, 1959.

PERSONNEL ACCESSWAYS

- a. Personnel Stairway and Bottom Access Stairway
3. AMF Report ER-TPS-250, WS 107A-2 Launcher System Facility Maintenance Access Study OSTF, 12/30/59.
4. AMF Report ER-TPS-257, WS 107A-2 Launcher System Facility Maintenance Access Study Training Facility-1, 1/15/60.
5. AMF Drawing No. HF-T-1056 (4 Sheets) Personnel Stairway Layout OSTF-TB.
6. AMF Drawing No. SK 194-10602 - Crib Stairway Study.

PERSONNEL SAFEGUARDS

- a. Emergency Ladders
7. ASA-A14.3-1956, American Safety Code for Fixed Ladders.
8. Safety Tower Ladder Company, Inc., New York, New York, Catalog and Safety Device Specifications.
9. AMF Document, TS 7.2.24, DDL Review - SK-194-20757 - Emergency Ladder Face D, 9/9/59.

10. Vendor Drawing No. JL-981-1-C, Cage Ladder, Aluminum Ladder Co., Worthington, Pa.

11. AMF Drawing No. HF-T-1085 - Access Ladder OSTF & Up.

12. AMF Drawing No. SK 194-90544 - Platform Bridge to Emergency Ladder.

b. Safety Nets

13. Technical Directive, Space Technology Laboratories, Inc., P. O. 95001, Los Angeles, California, Launcher Design Changes, 12/29/58.

14. AMF Drawing No. HF-T-1061 - Stage I Engine Access Safety Net Study.

c. Guard Rails

15. AMF Document, CR VB-0095, 10/6/60.

16. AMF Drawing No. HF-T-1067 - Catwalk Stairway to Bridge, OSTF - TB.

17. AMF Drawing No. HF-T-1104 - Bridge & Catwalk Guard Rail Modifications, OSTF & TF-1.

18. AMF Drawing No. HF-T-1138 - Catwalk and Bridge Handrail Study.

CONTAMINATION SAFEGUARDS, PREVENTIVE PROCEDURES

Selection and Chemical Handling of Hazardous Materials

19. Article, Don't Use Carbon Tet, Modern Sanitation and Building Maintenance, March, 1959.

20. AMF Report, ER-TPS-143, Carbon Tetrachloride As A Cleaning Agent (Personnel Safety), 11/14/58.
21. AMF Report, ER-TPS-166, Preliminary Lox Spillage Analysis, 1/8/59.
22. AMF Report, ER-TPS-184, Toxicity Analysis in the Silo, 2/24/59.
23. AMF Report, FTR-TPS-156, Spark Ignition Tests of Ucon Hydraulic Fluids, 3/23/59.
24. AMF Report, FTR-TPS-82, Corrosion and Other Environmental Effects of Equipment Components at Canaveral, 8/25/58.

CONTAMINATION SAFEGUARDS, PROTECTIVE PROCEDURES

Shower & Eye Wash Station

25. AMF Document (AF 04(647)-138), Preliminary Design Specification Emergency Shower and Eye-Wash Station for WS 107A-2 Launcher System, 2/16/59.
26. AMF (AF 04(647)-138), Design Specification for Emergency Shower and Eye Wash Station.
27. ADS-1073, Emergency Shower and Eye-Wash Station, 7/3/59.
28. AMF Report, ER-TPS-150A, Addendum to ER-TPS-150A, Effects on Launcher Design Due to Lowered Silo Temperature, 1/15/59.
29. AMF Report, MR #1125, Titan Emergency Shower & Eyewash, 3/24/59.

30. AMF Drawing No. HF-T-1111 (6 Sheets) Emergency Shower & Eye Wash Location Study.

SAFEGUARDS AGAINST HUMAN INITIATED FAILURES

31. AMF Report, ER-TS 7.1.15, Coding of Valves for the Titan Launcher System, 9/5/61.
32. AMF Report, ER-TS 7.1.39, Human-Initiated Failures at the Titan TF and OB Silos, 10/9/61.

Chapter 25

Human Factors Review and Evaluation
of the
Utilities

DOWN TIME



Adequate access for maintenance is essential to minimize down time and to keep the Launcher System in a ready state for the fulfillment of its mission.



PLATFORMS



Extensive platform arrangements were studied and recommended to improve access throughout the Launcher Silo.

SAFETY HOOKS



Safety hooks (for safety belt attachment) have been recommended in those areas where ladders and catwalks have been considered superfluous due to an expected low frequency of maintenance access requirements.



ACCESS



All utility junction boxes, connection boxes, valves and manifolds must be accessible to Air Force maintenance crews.

HANDLING



Eye hooks have been recommended for all manifolds and junction boxes over 35 lbs. so that hoisting devices can be easily attached.

FIGURE 25-1
HUMAN FACTORS INPUTS
UTILITIES

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: UTILITIES									
	Human Factor Effort Required				PHASE IN STAGE		HUMAN FACTORS OBJECTIVE		APPLICABLE ON MODEL
	Concept Review	Analysis	Field Input	Specification Compliance Safety	Operational Status	Maintenance Recommendation	Product Improvement		
OSTF TF OB									
- SYMBOL									
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 Anthropometric Compatibility	*	*	*	*	*	*	*	*	
1.2 Controls and Displays	*	*	*	*	*	*	*	*	
1.3 Fail-Safe Design	*	*	*	*	*	*	*	*	
1.4 Malfunction Detection	*	*	*	*	*	*	*	*	
2.0 MAINTENANCE FACTORS									
2.1 Access, Visual	*	*	*	*	*	*	*	*	
2.2 Access, Servicing	*	*	*	*	*	*	*	*	
2.3 Remove and Replace	*	*	*	*	*	*	*	*	
2.4 Handling, Physical Limitations	*	*	*	*	*	*	*	*	
2.5 Handling, Transportation	*	*	*	*	*	*	*	*	
2.6 Vehicle Maneuverability	*	*	*	*	*	*	*	*	
3.0 SAFETY FACTORS									
3.1 Chemical Decontamination	*	*	*	*	*	*	*	*	
3.2 Escape Provisions	*	*	*	*	*	*	*	*	
3.3 Protection from Entanglement	*	*	*	*	*	*	*	*	
3.4 Protection from Falling	*	*	*	*	*	*	*	*	
3.5 Safety Devices (other)	*	*	*	*	*	*	*	*	
3.6 Warning Devices	*	*	*	*	*	*	*	*	
4.0 PHYSIOLOGICAL FACTORS									
4.1 Biological Damage	*	*	*	*	*	*	*	*	
4.2 Vertigo	*	*	*	*	*	*	*	*	
4.3 Vibration Effects	*	*	*	*	*	*	*	*	
5.0 PSYCHOLOGICAL FACTORS									
5.1 Fear of Heights	*	*	*	*	*	*	*	*	
5.2 Fear of Being Crushed	*	*	*	*	*	*	*	*	
5.3 Fear of Falling	*	*	*	*	*	*	*	*	
5.4 Fear of Isolation	*	*	*	*	*	*	*	*	
5.5 Feeling of Insecurity	*	*	*	*	*	*	*	*	
6.0 ENVIRONMENTAL FACTORS									
6.1 Acoustic Energy (noise)	*	*	*	*	*	*	*	*	
6.2 Humidity & Temperature	*	*	*	*	*	*	*	*	
6.3 Illumination	*	*	*	*	*	*	*	*	
7.0 HUMAN USE FACTORS									
7.1 Procedure	*	*	*	*	*	*	*	*	
7.2 Time Study	*	*	*	*	*	*	*	*	
7.3 Training/Selection	*	*	*	*	*	*	*	*	

FIGURE 25-2

1.0 DESCRIPTION

- 1.1 The utilities consist of the hydraulic and water piping with their associated valves (manual and automatic) manifolds, cylinders, snubbers, and all electrical conduit connected to junction boxes, key switches, limit switches, push button stations, utility outlets, etc. This supporting control equipment is located at various elevations throughout the crib and launcher structure and in a few instances on the silo wall.
- 1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to remove, replace or service efficiently all utility components that may require attention. The operations or methods used should not cause injury to personnel or damage to equipment. Factors contributing to the successful servicing of the utilities have been itemized on the summary checklist (Fig. 25-2) and the progress of this design effort has been tabulated in the following synopsis.

ITEM: UTILITIES (REMARKS & REVISIONS)											200
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		RECOMMENDATIONS	VERIFICATION		RESULTS		
	CONTRACTUAL ACTION 52-4A	TECH. REF.		PARTICIPATION	ANALYSIS/TEST						
2.4 BASELINE, PHYSICAL LIMITATIONS	6.3.1.1		THE WEIGHT OF A REMOVABLE UNIT TO BE MARKED BY PERSONNEL SHALL NOT EXCEED 35 LBS.			IF A REMOVABLE EXCEEDS 35 LBS. - THE RECORD ATTACHED TO THE FORM SHOULD BE USED TO MARK THE UNIT.			PARTIALLY ADOPTED	10	
3.0 SAFETY FACTORS											
3.1 PROTECTION FROM FALLING	7.5, 7.6, 7.9	48-3003C	SNIP OR CANNON ARMED HANDFOOT IS IN PLACE 3 (WITH SAFETY NET ATTACHED).	SELF-PROPS		RECORDED THE PLACING OF SAFETY NETS IN AREAS CONSIDERED TO BE HAZARDOUS OR SETBACK; THIS SHOULD BE DONE BY A QUALIFIED MAINT FACTORS INSPECTOR FAMILIAR WITH THE		1	PARTIALLY ADOPTED	20	
3.5 SAFETY DEVICES	7.6, 7.7, 7.11, 7.15, 7.19, AND 7.22	48-3003C 3.2.7.2, 3.3 AND 3.5	SAFETY NETS.								
5.0 PERFORMANCE FACTORS											
5.3 FEAR OF FALLING	7.5, 7.6, 4 7.9	48-3003C	ALL UTILITIES MUST BE ACCESSIBLE WITHOUT THE DANGER OF FALLING.	SEE REVISIONS SECTION NUMBER 1 THIS IS FOR REVISIONS MADE IN PARTICIPATION.		RECORDED PLATFORMS THROUGHOUT THE SITE FOR COMPLETE COVERAGE OF EQUIPMENT AREAS.		1	NOT ADOPTED	10	
6.0 ENVIRONMENTAL FACTORS											
6.3 ILLUMINATION	5.5, 5.5.1, 5.5.2, 5.5.3 7.2.1 AND TABLE 3.		ALL AREAS SHOULD BE ILLUMINATED BY 25 TO 100 FOOT CANDLES.			SEE PREVIOUSLY REVISIONS LIGHTING CONDITIONS.			NOT AVAILABLE.		
7.0 HUMAN USE FACTORS											
7.1 PERFORMANCE			REAR FACTORS INCLUDE FAMILIAR WITH THE LANDING POSITION AND THE ONE AVAILABLE FROM GROUND TOWER ACCESS IF NOT ABLE TO REACH EQUIPMENT THEN DETAILED REPORT ON SHOULD TO BE USED WHEN IN CONTACT WITH BACK POSITION AREA.	80-4/8-2013		RECORDED INFORMATION ACCESS TO UTILITIES TO MAKE REPAIRS TO WELL NOT BE TYPED FOR RECORDED RECORDS OF THE USE TO SPECIAL ACCESS REQUIREMENTS.		1	PARTIALLY ADOPTED	10	

3.0 DISCUSSION

- 3.1 The utilities have not been placed in the most accessible areas due to over-riding considerations of design and delivery. Approximately 46% are directly accessible, 17% require use of the mobile work platform, accessory work stand, or a ladder, and the balance can be made accessible using rigging techniques. Human Factors recommends placing safety hooks in areas considered marginal or below with respect to access. There are areas throughout the silo and crib that contain only a few components. Installation of an elaborate access approach is not warranted if relatively safe access can be provided by installing field located safety hooks to be used by personnel wearing safety belts. These areas should be determined by a qualified Human Factors engineer familiar with Titan. Many areas need additional light for safe working conditions because the buildup of equipment has blocked or reduced existing light sources.
- 3.2 During the original concept stages Human Factors had proposed many platforms and other methods of access most of which were not accepted because of austere design and schedule requirements. After removal of all installation scaffolding, the need for additional access became evident.

4.0 BASIC REFERENCES

1. AFEM 57-8A, Human Engineering Design Standards for Missile System Equipment.
2. AFEM Technical Directive 59-4021 - Maintenance Access in the Missile Silo.
3. AMF Design Specification 1003C, Personnel Safety for WS 107A-2 Launcher System.
4. AMF Design Specification 1078, Facility Access Platforms for WS 107A-2 Launcher System.
5. AMF Procedure Specification 1070A, Formation and Application of a Reference Designation System for Hydraulic and Water Utility Lines and Components Within the WS 107A-2 Launcher System.
6. AMF Report, ER-TPS-223 - Access for Maintenance-Manifolds Crib Mounted.
7. AMF Report, ER-TPS-231 - Access for Maintenance Junction Boxes.
8. AMF Report, ER-TPS-192 - OSTF Door Foundation Interference (Utilities, Hyd.).
9. AMF Report, ER-T/S-5103 - Human Factors Field Test Access VAFB.
10. AMF Report, MR-TPS-111 - In Silo Maintenance Study.

4.1 DRAWING REFERENCES

1. AMF Drawing No. HF-T-1000 - Access Ladders.
2. AMF Drawing No. HF-T-1003 - Test Plug Connections and Disconnections.
3. AMF Drawing No. HF-T-1004 - Basic Data Access Areas via Hand Reach, Ladder & Mobile Platform.
4. AMF Drawing No. HF-T-1005 - Utilities Access Area - (Ref. Data).
5. AMF Drawing No. HF-T-1006 - Access Area Bay 1.
6. AMF Drawing No. HF-T-1007 - Access Area Bay 2.
7. AMF Drawing No. HF-T-1008 - Access Area Bay 3.
8. AMF Drawing No. HF-T-1009 - Access Area Bay 4.
9. AMF Drawing No. HF-T-1010 - Access Area Bay 5 & 6.
10. AMF Drawing No. HF-T-1011 - Access Area Bay 7 & 8.
11. AMF Drawing No. HF-T-1035 - Test Plug Pin Connection Schematic.
12. AMF Drawing No. HF-T-1036 - Platform, Top Crib Access Face A.
13. AMF Drawing No. HF-T-1037 - Access - Top of Silo (Quad. IV) TF & OB.
14. AMF Drawing No. HF-T-1043 - Proposed Modifications - Face "A" Bay 3 (Personnel Envelope).
15. AMF Drawing No. HF-T-1044 - Access Ladder Cold Helium Line Valves @ 378'-4" Quad. II.

16. AMF Drawing No. HF-T-1045 - Study Valve Access Quad. II, Face A
Between #1 & #2 Work Platform.
17. AMF Drawing No. HF-T-1046 - Access Study Personnel Elevator to Sump.
18. AMF Drawing No. HF-T-1049 - Access Top of Launcher Platform.
19. AMF Drawing No. HF-T-1062 - Access Envelope Launcher Platform Seal
& Umbilical Junction Box.
20. AMF Drawing No. HF-T-1063 - Alternate Guide Roller Access Layout.
21. AMF Drawing No. HF-T-1065 - Upper Silo Access Layout.
22. AMF Drawing No. HF-T-1067 - Cat Walk Stairway to Bridge (OSTF & TF).
23. AMF Drawing No. HF-T-1068 - Platform Envelope at #8 Elevator Stop. .
24. AMF Drawing No. HF-T-1069 - Study - Access Area to Work Platform #5.
25. AMF Drawing No. HF-T-1090 - Stairway Study Elevation 380'-392'.
26. AMF Drawing No. HF-T-1122 - TF & OB Leak Check Envelope -
Elevation 355'-9".
27. AMF Drawing No. HF-T-1119 TF-1 Leak Check Envelope - El. 307'-5 $\frac{1}{4}$ ".

Chapter 26

Human Factors Review and Evaluation
of the
Work Platforms



OBSTRUCTION



Railings stored at the elevator entrance prohibit free access to and from the elevator. Guard rails should be stored in the same quadrant in which they are used and out of passageways.



COLOR CODING



Underside of folding tabs have been caution striped to indicate that they are not in position.

ACCESS



All parts must be accessible for easy remove and replace.

FAIL SAFE



Work Platform over-center linkage design prevents collapse in the event of power failure.

FIGURE 26-1
HUMAN FACTORS INPUTS
WORK PLATFORMS

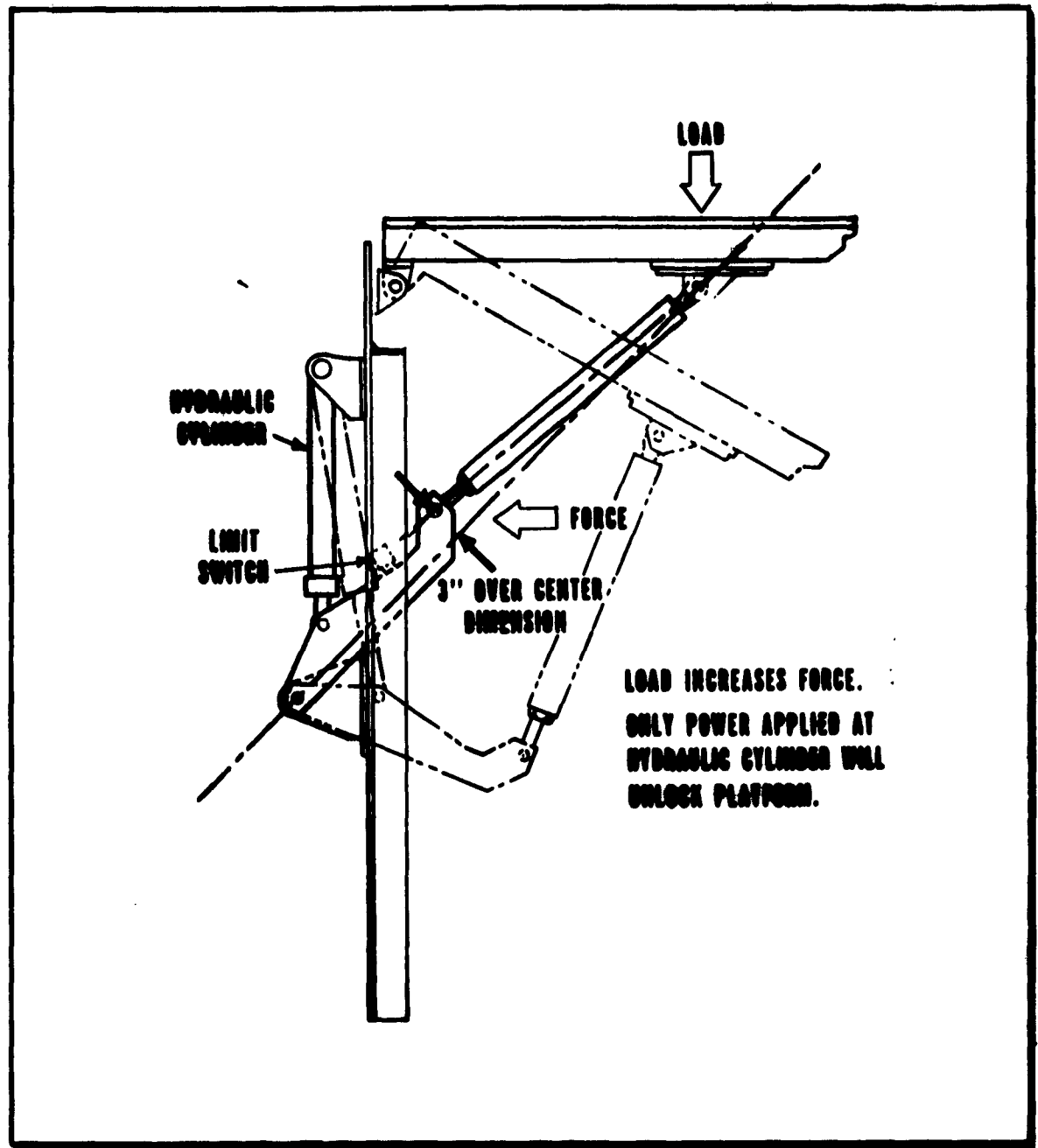


FIGURE 26-2
FAIL SAFE WORK PLATFORM
DESIGN

FEELING OF SECURITY



Feeling of security has been provided by expanded metal sheeting which prevents falling between the railings and restricts the visual awareness of height.



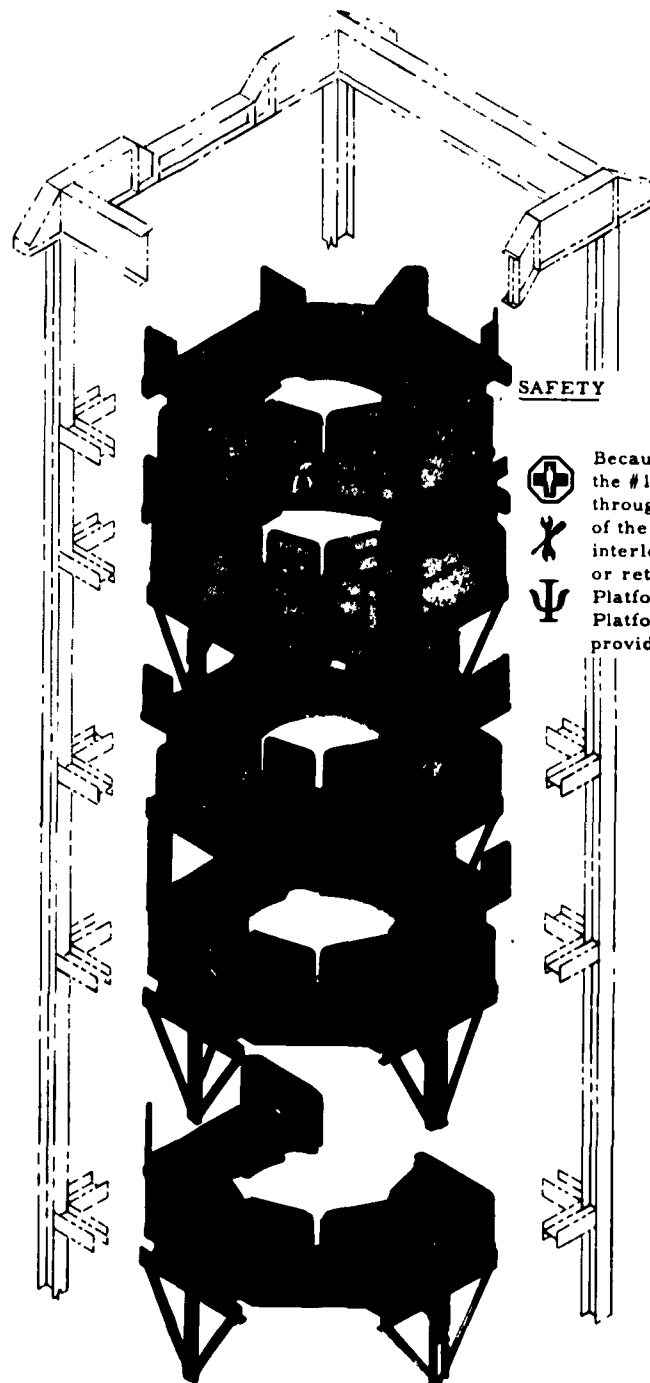
HANDLING



Handrail sections should be simplified for ease of emplacement.



FIGURE 26-3
WORK PLATFORM
GUARD RAILS



SAFETY



Because a down folding leaf of the #1 Work Platform passes through the personnel envelope of the #2 Work Platform, an interlock preventing extension or retraction of the #1 Work Platform when the #2 Work Platform is extended has been provided.

**FIGURE 26-4
RETRACTABLE
WORK PLATFORM
LEVELS**

SUMMARY CHECKLIST OF HUMAN FACTORS PROGRAM IN RELATION TO: WORK PLATFORMS										HUMAN Factor Effort Required		PHASE IN STAGE	HUMAN FACTORS OBJECTIVE	APPLICABLE ON MODEL	SYMBOL													
										Concept Review	Analysis	Field Input	Specification Compliance	Operational Status		Maintenance Recommendation	Product Improvement	OSTF	TF	OB								
1.0 HUMAN ENGINEERING DESIGN FACTORS																												
1.1	Anthropometric Compatability	*	*	*	*	*								*	*	*												
1.2	Controls and Displays	*	*	*	*	*								*	*	*												
1.3	Fail-Safe Design	*	*	*	*	*				*	*	*	*	*	*	*												
1.4	Malfunction Detection	*	*	*	*	*				*	*	*	*	*	*	*												
2.0 MAINTENANCE FACTORS																												
2.1	Access, Visual															*	*	*										
2.2	Access, Servicing	*	*	*	*	*		*	*							*	*	*										
2.3	Remove and Replace	*	*	*	*	*		*	*							*	*	*										
2.4	Handling, Physical Limitations	*	*	*	*	*		*	*							*	*	*										
2.5	Handling, Transportation																											
2.6	Vehicle Maneuverability																											
3.0 SAFETY FACTORS																												
3.1	Chemical Decontamination															*	*	*										
3.2	Escape Provisions	*	*	*	*	*		*	*							*	*	*										
3.3	Protection from Entanglement																											
3.4	Protection from Falling	*	*	*	*	*		*	*							*	*	*										
3.5	Safety Devices (other)	*	*	*	*	*		*	*							*	*	*										
3.6	Warning Devices																											
4.0 PHYSIOLOGICAL FACTORS																												
4.1	Biological Damage																											
4.2	Vertigo																											
4.3	Vibration Effects																											
5.0 PSYCHOLOGICAL FACTORS																												
5.1	Fear of Heights	*	*	*	*	*		*	*							*	*	*										
5.2	Fear of Being Crushed																											
5.3	Fear of Falling	*	*	*	*	*		*	*							*	*	*										
5.4	Fear of Isolation																											
5.5	Feeling of Insecurity	*	*	*	*	*		*	*							*	*	*										
6.0 ENVIRONMENTAL FACTORS																												
6.1	Acoustic Energy (noise)																											
6.2	Humidity & Temperature																											
6.3	Illumination	*	*	*	*	*		*	*							*	*	*										
7.0 HUMAN USE FACTORS																												
7.1	Procedure	*						*								*	*	*										
7.2	Time Study																											
7.3	Training/Selection																											

FIGURE 26-5

1.0 DESCRIPTION

1.1 The basic concept for the design and location of Work Platform levels was established to provide missile access and maintenance to the umbilicals. An additional consideration was access to AMF and associate contractor's crib mounted utilities.

There are five work platforms located one each at the following elevations: 379'-6", 370'-6", 355'-9", 342'-3", and 323'-7".

Each platform level is divided into segments which fold hydraulically against the inner faces of the crib. Levels 1, 2, 3, and 4 are comprised of four segments while level 5 is restricted to three segments by the umbilical loop envelope. Manually folded and unfolded leaves bridge the gaps between each segment so that personnel and equipment can move around the circumference of the missile. Electrical interlocks provide assurance that every leaf is folded and locked to the main segment before retraction can be started, since an unfolded leaf would interfere mechanically with cable, guide rollers, etc., when the segment is fully retracted. Key switch stations provide protection to personnel working on a specific level. The removal of a key from either of two stations prevents actuation of the retraction mechanism controls for that level. Kickplates and removable guard rails 42" in height are provided to improve safety factors. There is a flexible trough (platform-to-missile seal) on all work platforms adjacent to the missile. This trough prevents tools from dropping off the platform.

1.2 Men of the Air Force population who represent body sizes between the 5th and 95th percentile must be able to control and use the work

platforms easily and safely. The extended platforms must provide adequate area to maneuver maintenance vehicles, and their related components should be designed for ease of maintenance.

Factors contributing to the successful use of the work platforms have been itemized on the summary checklist (Fig. 26-5) and the progress of the design program relating to the work platforms has been tabulated in detail in the following synopsis.

ITEM: MOSE PLATFORMS									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	RELATIVE VALUE
	CONTRACTUAL AFM 57-8A	TECH REF.		PARTICIPATION	RECOMMENDATIONS	ANAL	EQUIP TEST		
1.0 HUMAN ENGINEERING DESIGN FACTORS									
1.1 ANTHROPOMETRIC COMPATIBILITY	6.1.1.1	AMB-200A	PERSONNEL RANGING IN SIZE FROM THE 5TH TO THE 95TH PERCENTILE MUST BE ABLE TO USE THIS EQUIPMENT EFFICIENTLY AND SAFELY.	PERSONNEL MUST BE ABLE TO PERFORM THE 5TH TO THE 95TH PERCENTILE V.P. TO SERVICE MISSILE PER WA-775-106.	RECOMMENDED INCREASE IN WIDTH OF PLATFORMS TO IMPROVE ACCESSIBILITY AND ELIMINATE SOME OF POULING TIPS.			NOT ADOPTED.	5
1.2 CONTROLS AND DISPLAYS	2.1.1.1, 2.3.1, 3.1.2.2.4, 3.1.3.1, 3.1.3.2, 3.1.3.3, 3.2.1	AMB-1003C 3.2.1, 3.2.5, 4.10, 4.11, 4.15, 5.0, 4.6.11B AMB-200A	FEED BACK TO SAFE GREEN LIGHTS MUST BE FROM MOSE PLATFORM SERVOINT LIMIT SWITCHES TO BE EFFECTIVE INDICATION OF SAFE CONDITION.	REVIEWED D.D.L. & E.P.D. FROM FOLDING SECTION OF #1 V.P. PASSES THEN PERSONNEL ENVELOPS OF #2 V.P. A TEST WAS CONDUCTED TO EVALUATE MOSE PLATFORM DESIGN AND CONTROLS WITH RESPECT TO ACCEPTABLE HUMAN FACTORS ENGINEERING PRINCIPLES. SEE INTY-F-2055, ANTHROPOM. 1.	RECOMMENDED CHANGE IN CIRCUMFERENCE TO PREVENT OPERATION OF #1 MOSE PLATFORM WHEN #2 V.P. IS EXTENDED.			#1 AND 2 INTERLOCKS (I.E. #1 DOES NOT OPERATE WHEN #2 IS EXTENDED).	10
1.3 FAIL SAFE DESIGN	1.4 AND 2.1.6	AMB-200A AMB-1003C	EFFORT SHOULD BE MADE TO ACHIEVE A FAIL SAFE DESIGN.	REVIEWED D.D.L. & E.P.D. BY F-176 AND BA-8-112 INT. A NO-59-2410.	TOES TO PERFORM TESTS ARE TABULATED IN THE ESSELE COLUMN.			0.2.1.2 (2 REM ENPLACE-1587) 0.2.1.5 (2 REM ENPLACE-1587) 0.5.0.6 (1 REM ENPLACE-1587) 0.4.1.3 (1 REM ENPLACE-1587)	10
2.0 MAINTENANCE FACTORS									
2.2 ACCESS, SERVICING	4.3.2.3, 4.3.3.7.1, 4.3.3.9.2, 4.3.3.9.4	AMB-200A	CONNECTION POINTS SHOULD BE ACCESSIBLE.	REVIEWED D.D.L. & E.P.D.	THE WILL REVIEW THEIR EQUIPMENT TO IMPROVE USE OF SPACE IN RELATION TO ANY EQUIPMENT.			V. PLATFORM OVER-CENTER DESIGN PREVENTS COLLAPSE DUE TO POWER FAILURE. THE FOUND ANY TWO THE TEAM ANTI-STATELY BANNED THE MOSE PLATFORMS AND RELATED AREAS.	5

2.0 SYNOPSIS

ITEM: NOISE PLATFORMS									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	RELATIVE VALUE
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANAL.	EQUIP/TEST		
2.4 HANDLING, PHYSICAL LIMITATIONS	h.3.3.1, h.2.2.1, h.3.3.4.8 & h.3.3.9.1.4	ADS-200AA	PROVISIONS SHOULD BE MADE FOR LIFTING WEIGHTS. (OVER 35 LBS.) SIDE LEAVES (TAMS) SHOULD BE LIGHT WEIGHT.	REVIEWED D.D.L. & E.P.D. APP-8-2055. REVIEWED D.D.L. & E.P.D. STAKE SEPARATION EQUIPMENT INTERFERENCE WITH LA W.P. ACTUATING MECHANISM. REVIEWED E.P.D.	REDUCE GUARD RAIL WEIGHTS AND SIMPLIFY THE SECTIONS TO MAKE THEM EASIER TO INSTALL. EXTENSION RAILINGS FOR FOLDING TAMS. GUARD RAILS SHOULD BE STORED IN THE SAME QUADRANT IN WHICH THEY ARE USED, SUGGEST EXTENSION RAILING ELIMINATING CURVED SECTIONS. GUARD RAILS WHEN STORED SHOULD NOT BLOCK ACCESS TO & FROM PERSONNEL ELEVATOR STUDIES MAKE SURE SHOWING POSSIBLE CHANGES IN GUARD RAIL STORAGE.	I	I - I	NOT ADOPTED. GUARD RAIL 1/2" & 1/4" ON MAIN PLATFORM WEIGHED 41 LBS. (SHOULD NOT EXCEED 35). NOT ADOPTED.	5
3.0 SAFETY FACTORS 3.2 ESCAPE PROVISIONS		ADS-200AA	PASSAGeways FOR ESCAPE SHOULD NOT BE OBSTRUCTED.	REVIEWED EPO EN # 219.		I		NOT ADOPTED. COST DID NOT MEET THE SLIGHT IMPROVEMENT TO BE REALIZED. AUTOMATIC FOLD GUARD RAILS NOT ADOPTED.	5
3.4 PROTECTION FROM FALLING	7.5, 7.8, & 7.9	ADS-200AA	PERSONNEL MUST BE PROTECTED FROM FALLING DUE TO FALLING.	REVIEWED D.D.L. & E.P.D.	ADAPT AUTOMATIC GUARD RAILS SUCH AS THOSE USED ON ABOVE GROUND SYSTEM. ALL NOISE PLATFORM OPEN EDGES SHOULD HAVE GUARD RAILS.	I		UNPROTECTED AREAS FILLED BY UNWEIGHT AND FIVE RAILINGS.	10
3.5 SAFETY DEVICES (OTHER)	7.19 & 7.22	ADS-1003C ADS-200AA	COLOR CODE ALL HAZARDOUS AREAS.	REVIEWED D.D.L. & E.P.D. RECOMMENDED THAT W.P. #1 & #2 BE INTERLOCKED FOR SPECIAL SEQUENCE. RAILINGS LEFT OFF #1 W.P. (MISSILE OUTING).	ADDITIONAL SAFETY DEVICES TO BE USED WHEN EXTENDING AND RETRACTING TAMS AND GUARD RAILS. COLOR CODE UNDERSTANDING OF FOLDING TAMS.	I	I	COLOR CODING OF NOISE PLATFORMS APPROVED.	10

ITEM: WORK PLATFORMS									
HUMAN FACTORS	DOCUMENTARY COMPLIANCE		CRITERIA FOR SUCCESS	APPLICATION OF CRITERIA		VERIFICATION		RESULTS	RELATIVE VALUE
	CONTRACTUAL	TECH. REF.		PARTICIPATION	RECOMMENDATIONS	ANAL.	EQUIP. TEST		
5.0 PSYCHOLOGICAL FACTORS									
5.1 FEAR OF HEIGHTS	SEE 3.4	AOS-2004A	RAILINGS MUST PROVIDE MAXIMUM PROTECTION FROM FALLING.	EA-TPS-82.	USE EXPANDED METAL OVER GARD RAIL OPENINGS.	I	I	WORK PLATFORMS HAVE EXPANDED METAL BETWEEN RAIL OPENINGS.	5
5.2 FEAR OF FALLING	SEE 3.4	AOS-2004A	EFFICIENT USE OF PROCEDURES REQUIRED WHEN OPERATING.						5
5.5 FEELING OF INSECURITY		AOS-2004A	INSECURITY MUST BE MINIMIZED.	REVISED DUL & EPD	RECOMMENDED COVER ON GARD RAILS TO OBSTRUCT VIEW BEYOND EDGE OF WORK PLATFORM.	I	I	COVERS ADDED TO GARD RAILS.	5
6.0 ENVIRONMENTAL FACTORS									
6.3 ILLUMINATION	5.5, 5.5.1, 5.5.3, & 7.21 TABLE 3	AOS-2004A	MUST WORK AREAS SECURE AT LEAST 25 FOOT CANTILES.			I		PRESENTLY BEING STUDIED BY DMC.	15
7.0 HUMAN USE FACTORS									
7.1 PROCEDURE			NO INTERFERENCE BETWEEN SECTIONS, ALL SECTIONS WHEN EXTENDED SHOULD HAVE SAME ELEVATION (IN RELATION TO WORK LEVEL).	ADPP-8-2055 (R.F. TEST PROCEDURE FOR EVALUATION OF THE WORK PLATFORMS.) ADPP-8-2055 (R.F. TEST PROCEDURE FOR WORK PLATFORM & GARD RAIL TEST. TESTS).		I	I	TEST INCOMPLETE.	
7.2 TIME STUDY			EFFICIENT USE OF TIME AS DETERMINED BY PROCEDURAL STUDY.	PROCEDURES PREPARED BUT NOT COMPLETED.		I	I	TEST INCOMPLETE.	
									100

2.0 SYNOPSIS

3.0 DISCUSSION

The work platforms were originally developed to satisfy missile access requirements. They are also used during maintenance operations for access to various components mounted on the crib structure such as umbilical mechanisms and utility lines. The basic design has remained relatively unchanged since its early concept, although several changes have been recommended which would improve the equipment with respect to safety and efficiency. Examples of these recommendations are as follows:

- a. Clearing access to the personnel elevator for easier passage to and from the work platforms,
- b. Storage of the guard rails in the same quadrant where they are used for faster, safer, and more efficient assembly and disassembly,
- c. Redesign of guard rails to straighten all curved sections for easier storage and to simplify manufacturing; extension handles for some of the platform folding tabs to reduce the hazard of falling; and redesign of some work platforms to improve accessibility, with the added possibility that some of the folding tabs would be eliminated to reduce the number of safety hazards.

During the design concept stage, Human Factors recommended automatic folding platform extension leaves and automatic guard rails which would insure optimum personnel protection and also decrease overall system maintenance time requirements. These recommendations were not incorporated into the Titan platform designs because austerity was considered to be

of prime importance. Experience in actual use with the existing work platforms will determine whether time and safety factors outweigh the initial cost of an automated system that may warrant retrofit at a later date.

4.0 REFERENCES

1. AFBM Exhibit 57-8A, Human Engineering Design Standards for Missile System equipment.
2. ADS-1003C, Personnel Safety for WS 107A-2 Launcher System.
3. ADTP-V-2055, Addendum A, Test Procedure for Exercising Launcher Work Platforms.
4. AHFP-V-2255, Human Factors Test Procedure for Work Platform and Guard Rail Installation Tests.
5. ADS-2004A, Design Specification Work Platforms for WS 107A-2 Launcher System.
6. AMF Report, MR-TPS-108, Personnel Must Reach 5'-0" from W. P. #1 to Service Missile.
7. AMF Report, ER-V-176, Work Platform Key Switches.
8. AMF Report, ER-V-142, Rev. A, Hazards in Operation of Work Platforms.
9. AMF Report, ER-TPS-219, Evaluation of Railing Storage for Work Platforms for WS 107A-2 Launcher System, TB & OB.
10. AMF Report, ER-TPS-202, Evaluation of Work Platforms for WS 107A-2 Launcher System for TB and OB.
11. AMF Report, ER-TPS-124, Crib Mounted Work Platform Locations.
12. AMF Drawing No. HF-T-1069, Study Access Area to Work Platform #5.

13. AMF Drawing No. HF-T-1101, Key Station for Work Platforms.

14. AMF Drawing No. HF-T-1112, Hazardous Marking Areas - Work
Platforms 1 thru 6.