DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CEMP-ET | ETL 1110-3-430

Technical Letter
No. 1110-3-430

23 September 1991

Engineering and Design
DESIGN OF U.S. ARMY AIRFIELD AIRCRAFT MOORING
AND GROUNDING POINTS FOR ROTARY WING AIRCRAFT

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Engineering and Design
DESIGN OF U.S. ARMY AIRFIELD AIRCRAFT MOORING AND GROUNDING POINTS FOR ROTARY WING AIRCRAFT

1. Purpose. This letter provides U.S. Army Corps of Engineers design guidance regarding Army Airfield rotary wing aircraft mooring and grounding points. This guidance provides design requirements for mooring points that will resist a 15,250 pound force applied at 19 degrees from the paving surface and grounding points that will have a resistance of less than 10,000 ohms.

2. Applicability. This letter applies to all HQUSACE, major subordinate commands, district offices, and field operating activities (FOA) having military construction and design responsibility, and all airfields and heliports on USACE real property.

3. References.

a. TM 1-1500-250-23 - General Tie-Down and Mooring on All Series Army Models AH-64, UH-60, CH-47, UH-1, AH-1, OH-58 Helicopters.

b. TM 5-803-4 - Planning of Army Aviation Facilities.

c. TM 5-811-3 - Lightening and Static Electricity Protection.

d. TM 5-824-4 - Army Airfield-Heliport Operational and Maintenance Facilities.

e. ANSI/IEEE Std 142 - Grounding Industrial and Commercial Power Systems.

f. CEMP-ET memorandum, 18 March 1990, Mandatory Installation of Mooring and Grounding Points to Protect U.S. Army Aircraft.

g. DAEN-ZCI memorandum, 9 April 1990, Installation of Mooring Points to Protect Army Helicopters.

This ETL supersedes ETL 1110-9-2(FR), dated 12 June 1990.

h. CEMRD-ED-GT memorandum, 2 October 1990, Army Aviation Systems Command/Army Corps of Engineers.

i. CEWES-GP-N report, 29 April 1991, Field Testing of Aircraft Mooring Points.

4. Background.

a. In the spring of 1989 Army aircraft at Fort Hood and Fort Polk experienced extensive and costly damage as a result of very high winds. The combat readiness of Army aircraft was adversely affected.

b. To prevent aircraft losses in the future, TM 1-1500-250-23 has been issued with an accompanying video training tape. This TM and videotape provide operational guidance for AH-64, UH-60, CH-47, UH-l, AH-1 and OH-SB rotary wing aircraft mooring points only.

5. Discussion.

a. TM 1-1500-250-23 increases mooring device design load to a 15,250 lb. resultant force at 19.15 degrees from the pavement surface.

b. Mooring points, designed in accordance with guidance in TM 5-824-4 dated April 1966 requiring tie-down anchors to be constructed of 5/8-inch diameter bimetallic copper-covered steel rods, were tested at various locations by Army personnel. The testing indicated that the existing criteria are not sufficient to meet mooring device design loads required by TM 1-1500-250-23.

c. CEWES tested several mooring/grounding point alternatives, which were reported in reference 3.i. The most economical alternatives that passed that testing program are presented in this ETL for field applications.

6. Action To Be Taken.

a. Requirements for New Mooring Points/Grounding Points. Unless specifically waived in writing by the Installation Commander, all new construction of Army aircraft parking aprons shall include aircraft mooring points designed for the 15,250 lb. loading specified in TM 1-1500-250-23. Grounding points shall have a resistance of less than 10,000 ohms as required in TM 5-811-3.

b. Evaluation of Existing Mooring Points. Extensive testing of existing mooring points installed in rigid (portland cement concrete) pavement indicates that they generally hold the expected loads, but will deform significantly at the design load of 15,250 lbs. Therefore, existing 5/8-inch diameter bimetallic copper-covered steel rods which are 6-feet long, are considered adequate for immediate aircraft protection provided the following conditions are met:

(1) The existing rods are installed in rigid pavement.

(2) The existing rods do not show signs of deformation or corrosion.

(3) The existing rods are inspected for deformation and corrosion at least once a year and after each storm with winds greater than 50 knots.

Any existing rods that exhibit deformation or corrosion shall be considered inadequate and require replacement. All existing 5/8-inch diameter, 6 foot long rods in flexible (asphalt) pavement (including those with a portland cement concrete block at the surface) require replacement.

c. Evaluation of New and Existing Grounding Points. The maximum resistance measured, in accordance with ANSI/IEEE Std 142, of new or existing grounding points, shall not exceed 10,000 ohms under normally dry conditions. If this resistance cannot be obtained, an alternative grounding system shall be designed.

d. Mooring Capacity. Mooring Location. Number and Layout of Mooring Points.

(1) Mooring Capacity. Unless specifically waived in writing by the Installation Commander, mooring capacity shall be sized to accommodate 100% of the authorized aircraft, assuming that transient aircraft mooring requirements will be met by protecting aircraft inside of existing hangars. If existing hangar space combined with aircraft mooring point locations will not provide sufficient wind protection for both the installation*s authorized aircraft and the transient aircraft, sufficient aircraft mooring points shall be added to ensure protection of all aircraft.

(2) Mooring Location. TM 5-803-4 authorizes the aircraft parking aprons to be sized for 85% of the authorized aircraft (75% operational parking, and 10% maintenance operational checks). The locations of the mooring points can be on pavements other than aircraft parking aprons. Also prepared turf surfaces areas are acceptable for rotary wing aircraft operations. If, in the opinion of the Installation Commander, airfield operational requirements cannot be met by mooring aircraft on other pavements or prepared turf surfaces, the parking apron size may be increased beyond 85% of the authorized aircraft in order to provide adequate mooring locations to protect aircraft from damage due to high winds.

(3) Number of Mooring Points. Each aircraft mooring location shall have six (6) mooring points in accordance with TM 1-1500-250-23. Although some aircraft only require four (4) mooring points, six (6) mooring points shall be installed to provide greater flexibility in types of aircraft to be moored at the mooring location. Six (6) mooring points for 100% of the installation*s authorized aircraft is the maximum number of mooring points authorized (see paragraph 6.d.(1) for mooring capacity). The allowable spacing and layout of the 6 mooring points is shown in Figure 1 of Enclosure 1. Unless operationally and economically justified in writing by the Installation Commander, a 20 foot by 20 foot mooring point grid pattern throughout the apron for mass aircraft parking aprons shall not be authorized. Figure 2 of Enclosure 1 shows the recommended pavement joint and mooring point spacing if this option is justified and authorized.

(4) Layout of Mooring Points. Aircraft parking layout shall be in accordance with TM-5-803-4 with the additional requirement that the largest diameter rotor blade for the installation*s assigned aircraft be used for locating the mooring points within the 80-foot by 80-foot, or 80-foot by 160-foot aircraft parking areas. Enclosure 2, aircraft geometry, is provided for aircraft parking layout requirements.

e. Mooring Points for New Rigid Pavement Equal to or Greater than 6 Inches Thick. Mooring points for new rigid pavements should be provided by embedding the mooring devices in fresh portland cement concrete. Each aircraft parking position should be provided with mooring points. The layout of points is shown in Figure 1 of Enclosure 1 with mooring points at least 2 feet from the new pavement joints. This will require close coordination between the parking plan and the jointing plan. The mooring devices should be as shown in Figure 3 of Enclosure 1 with pavement reinforcement around the mooring device as shown in figure 4 of Enclosure 1.

f. Mooring Points for Existing Rigid Pavement Equal to or Greater than 6 Inches Thick and in an Uncracked Condition. The following option should be used to provide mooring points for existing rigid pavement that is in an uncracked condition. The pavement should have only a few slabs with random cracks and should not exhibit “D” cracking. Mooring points should be provided by core drilling a 12-inch diameter hole through the pavement and installing a mooring device as shown in Figure 5 of Enclosure 1. Each aircraft parking position should be provided with 6 mooring points. The layout of the mooring points is shown on Figure 1 of Enclosure 1.

g. Mooring Points for Other Areas. The following options should be used to provide mooring points for rotary wing aircraft parked on the following surface conditions: Existing rigid pavement less than 6 inches thick; existing rigid pavement in a cracked or deteriorated condition; new flexible pavement; existing flexible pavement; grassed areas and other areas where appropriate.

(1) Option 1 - This option is the preferred option, and allows for the placement of a new concrete pad with a minimum thickness of 8 inches. The size of the pad should be a minimum of 24 feet wide by 44 feet long. The length and width may be increased to match the existing concrete from joint to joint for rigid pavement applications, six mooring points should be provided for each aircraft parking position with the layout of the mooring points as shown in Figure 6 of Enclosure 1. The mooring devices should be as shown in Figure 3 of Enclosure 1.

(2) Option 2 - This option allows the use of individual concrete piers for each mooring point as shown in Figure 7 of Enclosure 1. The diameter and length of the pier shall be based on the strength of the soil, and is given in figure 8 of Enclosure 1. Each aircraft parking position should be provided with 6 mooring points as required by TM 1-1500-250-23 (typical layout shown in Figure 1 of Enclosure 1).

h. Other Mooring Devices. Mooring devices other than the recommended options may be used provided they meet the load requirements and grounding requirements specified in paragraph 1. Load testing of the proposed mooring devices should be accomplished in the presence of a government engineer. Figure 9 of Enclosure 1 gives criteria of load tests.

i. Grounding Requirements. Grounding requirements for mooring devices are as follows. For the drilled pier application, the mooring device is exothermically connected to the reinforcing steel of the pier (see Figure 7 of Enclosure 1). For the flat slab application the mooring device should be mechanically connected to a 5/8 inch diameter bimetallic copper-covered steel rod that is 6 feet long (see Figure 3 of Enclosure 1). These grounding systems normally provide a static ground with a resistance of less than 10,000 ohms provided the soil resistivity is less than 2,000,000 ohm-centimeters.

7. Guide Specification. A draft guide specification for mooring points is provided in Enclosure 3.

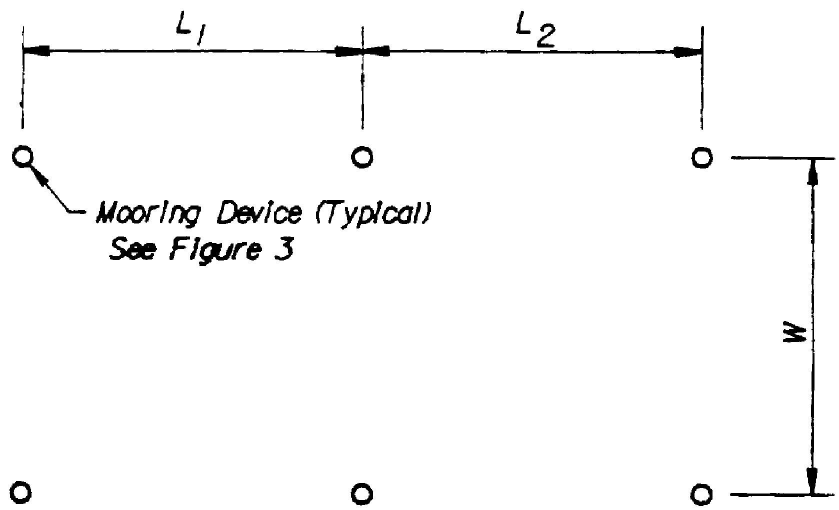
8. Implementation. This letter will have routine application as defined in paragraph 6.c., ER 1110-345-100.

FOR THE COMMANDER:

RICHARD C. ARMSTRONG, P.E.
Chief, Engineering Division
Directorate of Military Programs

3 Encls
Encl 1 - Design of U.S. Army Airfield Aircraft Mooring and Grounding Points for Rotary Wing Aircraft
Encl 2 — Aircraft Characteristics for Mooring and Grounding Points for Rotary Wing Aircraft
Encl 3 - Draft Guide Specification for Mooring and Grounding Points for Rotary Wing Aircraft at Army Installations

ALLOWABLE MOORING POINT SPACING



PLAN VIEW

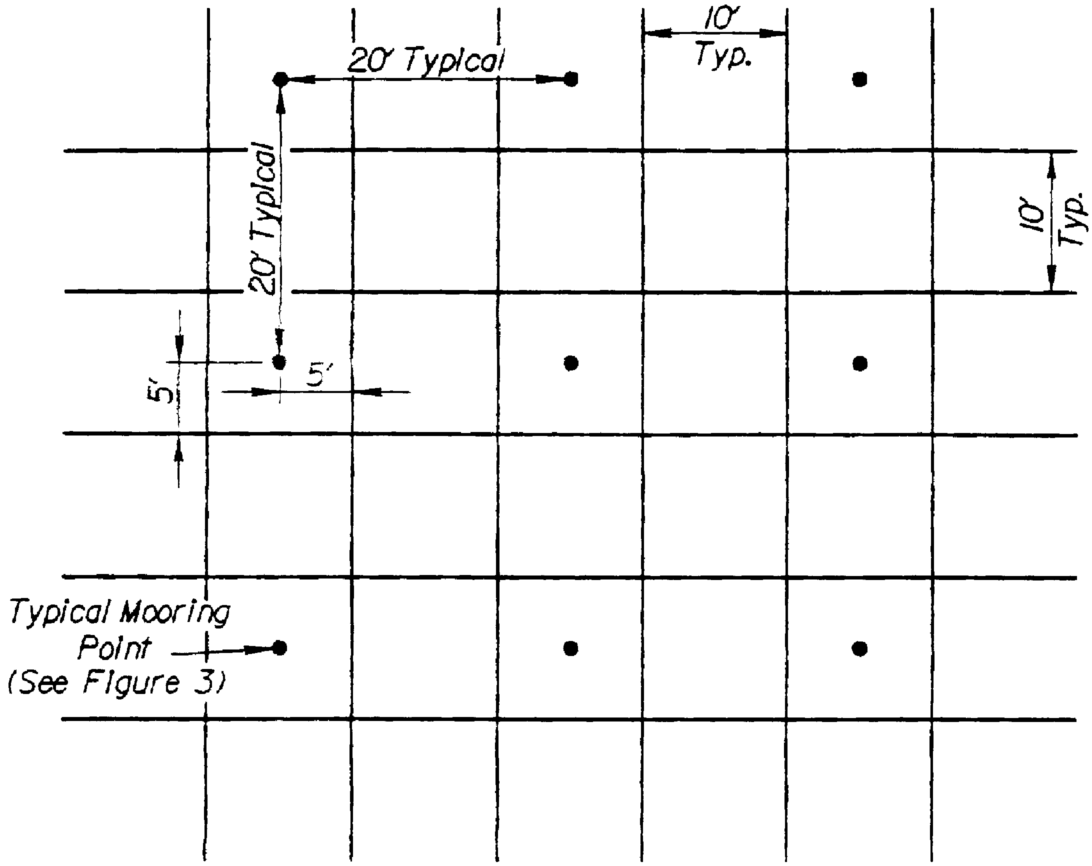
NOTES

1. The prefered mooring point spacing for each aircraft parking position is $L_1 = L_2 = W = 20.0'$.
2. In new or existing rigid pavement, the mooring points shall be at least 2 feet away from any pavement joint or edge. To miss the paving joints, the spacing of the mooring points may be varied as follows:
   - a. W, L_1 and L_2 may vary from 17 to 20 feet.
   - b. W, L_1 and L_2 need not be equal.
3. The construction tolerance on mooring point location should be ± 2 inches.

FIGURE 1

Encl 1

MOORING POINTS IN NEW RIGID PAVEMENT
(PAVEMENT THICKNESS ≥ 6")

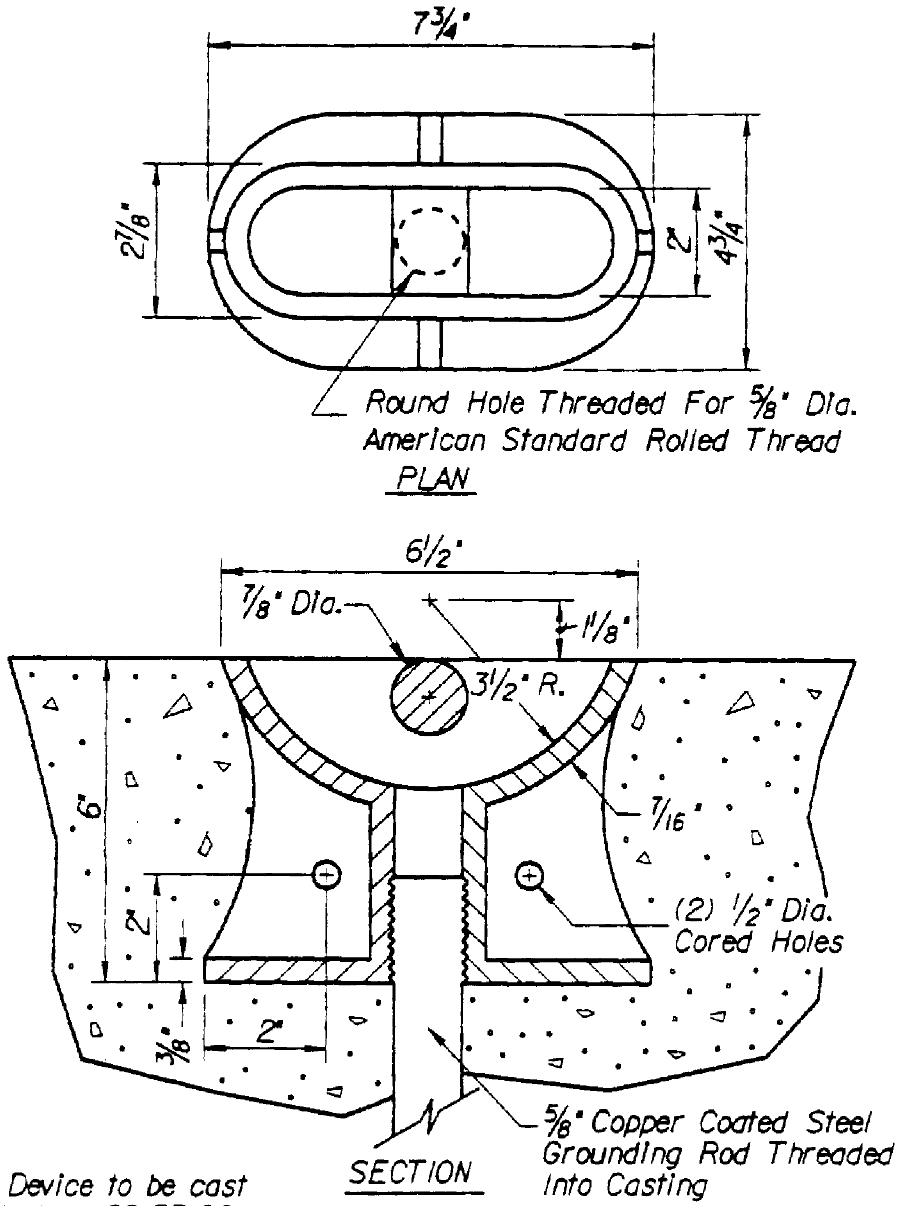


NOTE:

This is the recommended joint spacing for new concrete pavement where mooring devices are justified and authorized throughout the apron. Other joint spacings may be used as long as mooring devices are a minimum of 2-0' from joints and mooring devices are spaced as shown Figure 1.

FIGURE 2

MOORING DEVICE

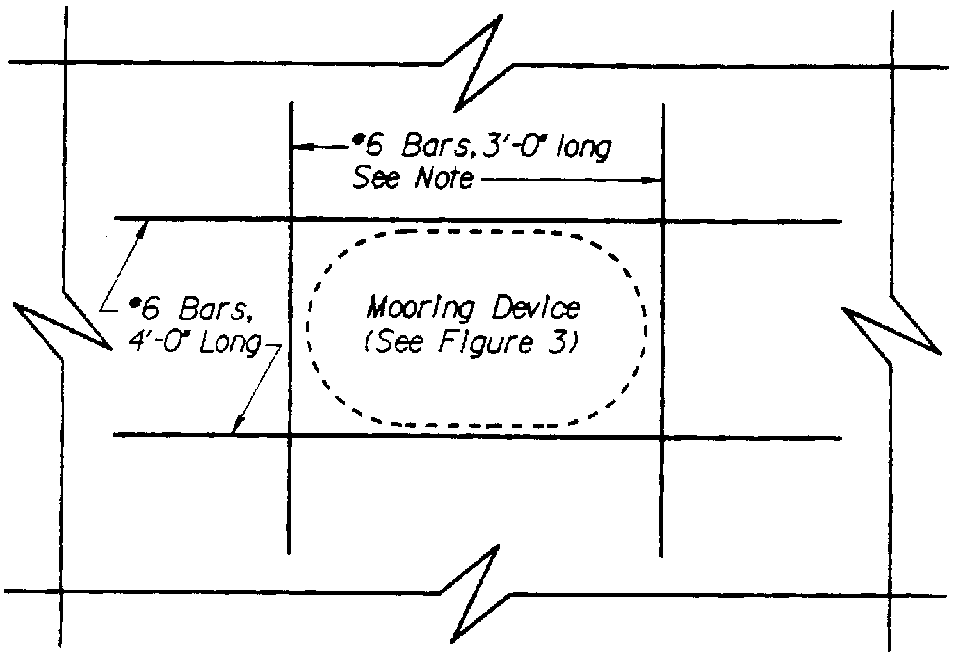


NOTE:

Mooring Device to be cast in Ductile Iron 80-55-06 or Equal

FIGURE 3

MOORING DEVICE REINFORCEMENT
(NEW SLAB)



PLAN VIEW

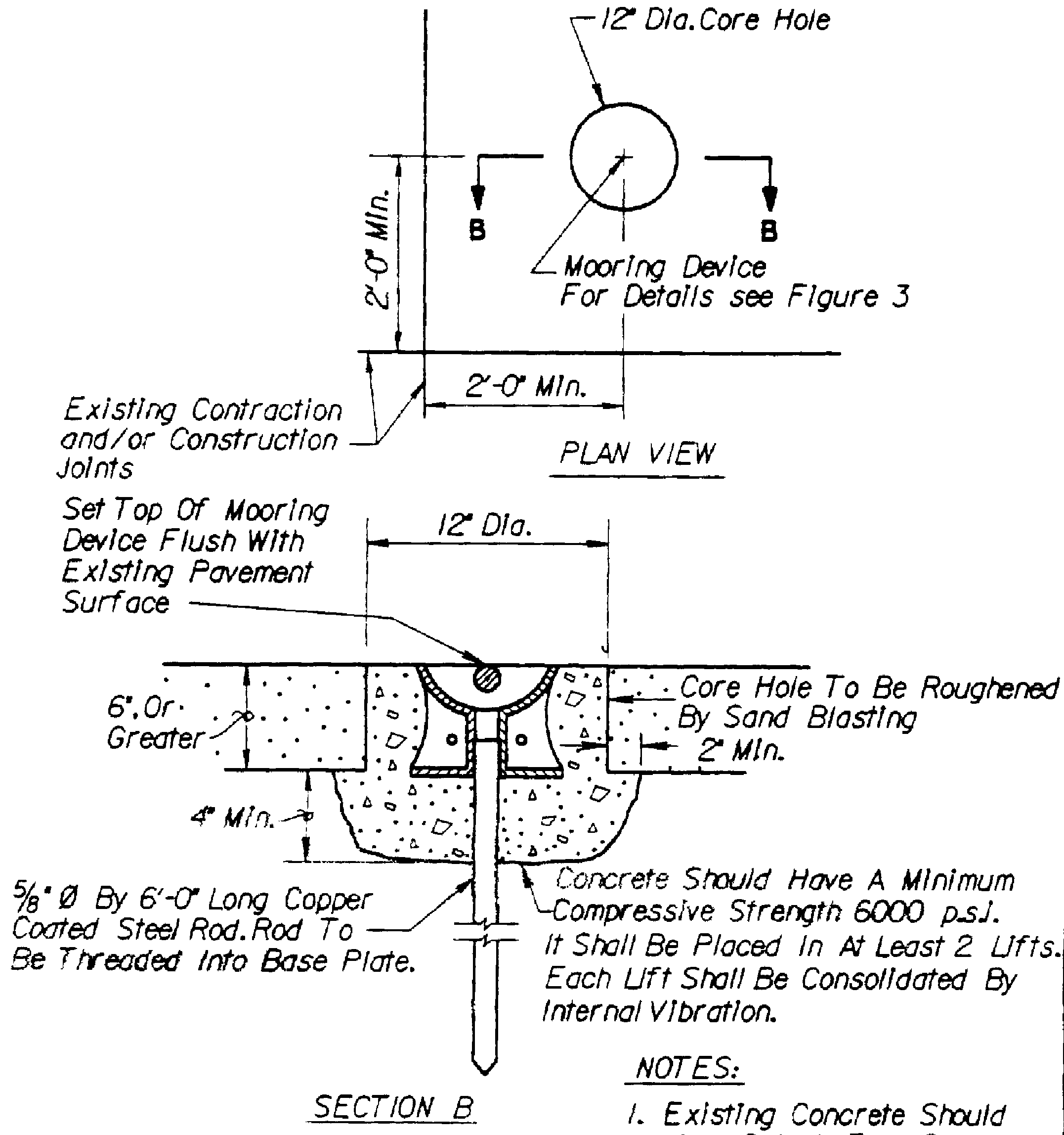
The ends of reinforcing bars should be placed 3 inches from paving

NOTE:

1. These *6 reinforcing bars should be placed 3 inches from mooring device and 3 inches below pavement surface.
2. The ends of reinforcing bars should be placed 3 inches from paving joints to provide cover.

FIGURE 4

MOORING POINT EXISTING RIGID PAVEMENT
(PAVEMENT THICKNESS ≥ 6 INCHES)
CORING OPTION

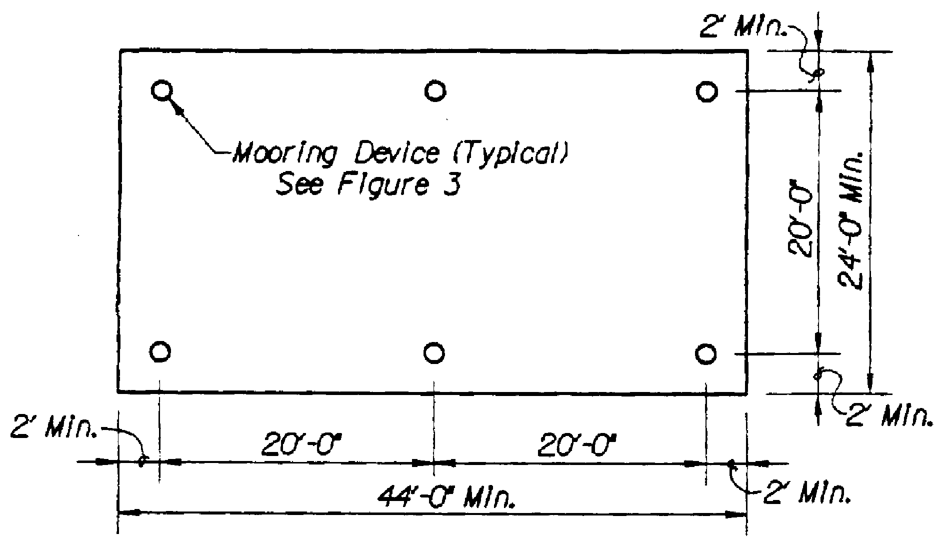


NOTES:

1. Existing Concrete Should Have Only A Few Slabs With Cracks If This Option Is To Be Used.

FIGURE 5

MOORING PAD DETAIL
(NEW OR EXISTING FLEXIBLE PAVEMENT, SEVERELY CRACKED RIGID PAVEMENT, OR GRASSED AREAS)



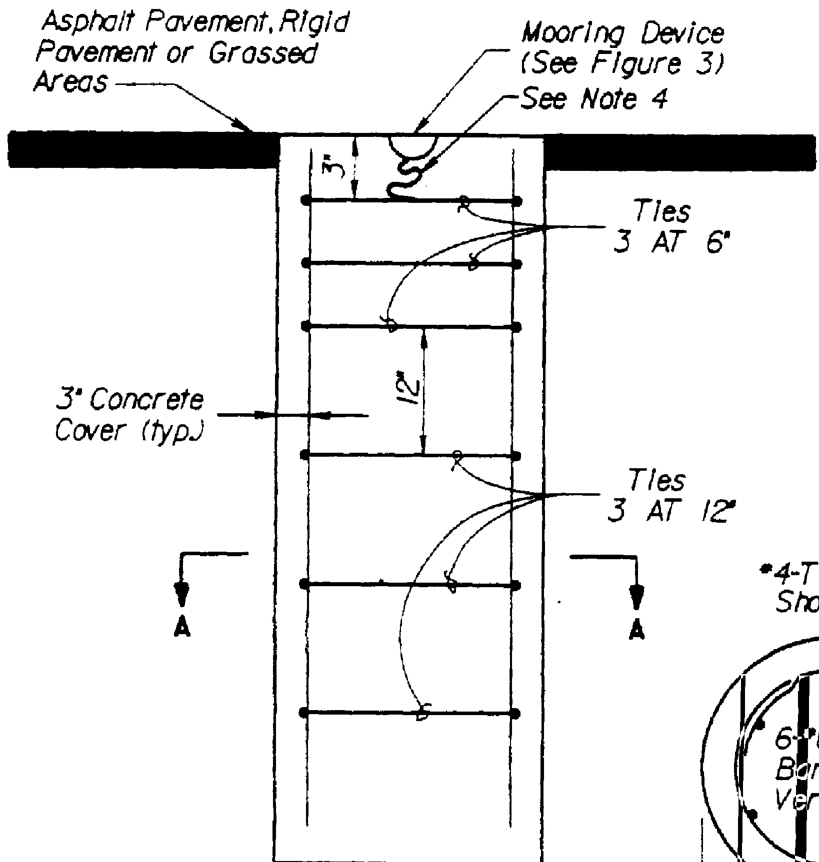
PLAN VIEW

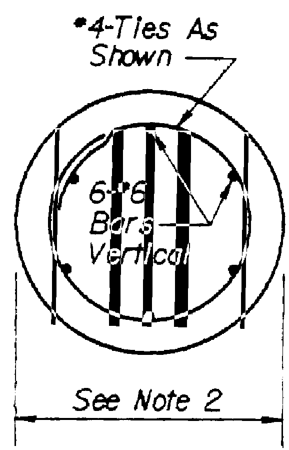
NOTES

1. This mooring pad is the prefered method of providing mooring points in grassed areas and in flexible pavements. For rigid pavement applications, the size of the pad should be increased to match the existing joint pattern.
2. Thickness of the pad should be designed to carry the expected aircraft loads, but not less than 8 inches.
3. The slab should be designed as a reinforced slab so that pavement jointing will not be required. If jointed pavement is desired, joint spacing should be adjusted so that mooring points are a minimum of 2' from pavement joints.
4. See Figure 4 for reinforcing adjacent to mooring device.
5. Typical prefered spacing for mooring devices is 20'. See Figure 1 for allowable mooring point spacing.

FIGURE 6

MOORING POINT FOR GRASSED AREAS, FLEXIBLE PAVEMENT OR RIGID PAVEMENT LESS THAN 6 INCHES THICK





SECTION A

NOTES

1. Core drill asphalt pavement.
2. or pier length and diameter, see Figure 8.
3. Spiral reinforcement equivalent to the *4 ties may be used.
4. Connect mooring device to reinforcing steel with *4 copper conductor exothermically welded in two places.
5. See Figure 1 for allowable mooring point spacing.

FIGURE 7

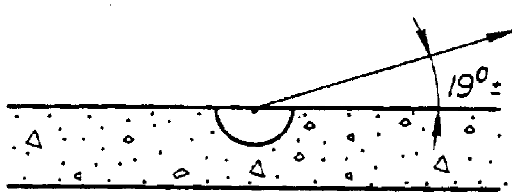
PIER LENGTHS AND DEPTHS

COHESIVE SOILS		
UNCONFINED COMPRESSIVE STRENGTH, q_u IN P.S.F.	PIER DIAMETER	PIER LENGTH
$q_u < 1000$	2'-0"	6'-0"
$1000 < q_u < 4000$	1'-6"	6'-0"
$q_u > 4000$	1'-6"	4'-0"

COHESIONLESS SOILS		
FRICTION ANGLE Ø IN DEGREES	PIER DIAMETER	PIER LENGTH
$Ø < 20$	2'-0"	7'-0"
$20 \leq Ø < 30$	2'-0"	6'-0"
$Ø \geq 30$	1'-6"	6'-0"

FIGURE 8

LOAD TESTING OF MOORING POINTS



NOTES:

1. Mooring point tests should be accomplished using a hydraulic ram or similar device and an appropriate reaction (heavy vehicle, etc.) that is capable of applying a tensile load of 16,000 lbs.
2. The length of the mooring chain and connecting shackle should be selected in such a way that an angle of 19.15° from the pavement surface (see above figure) can be maintained during load testing.
3. Appropriate safety precautions should be taken at all times during load testing operations.
4. The mooring points should be loaded in 2,500 lb. increments up to 10,000 lbs. and in 1,000 lb. increments up to 16,000 lbs. with each load increment held for at least 60 seconds.
5. To pass test requirements, mooring points shall not deform permanently under the 16,000 lb. load.

FIGURE 9

Aircraft Characteristics for
Mooring and Grounding Points for Rotary Wing Aircraft

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	56.0	56.0	36.2	42.4	10.1	5.3	10.8	7.8	†	†	6.3	†

SILHOUETTES NOT AVAILABLE

Figure C-111. Aerospatiale 315B, Lama

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	85	85	49.5	59.8	16.9	13.2	7.9	†	†	10.0	14.4

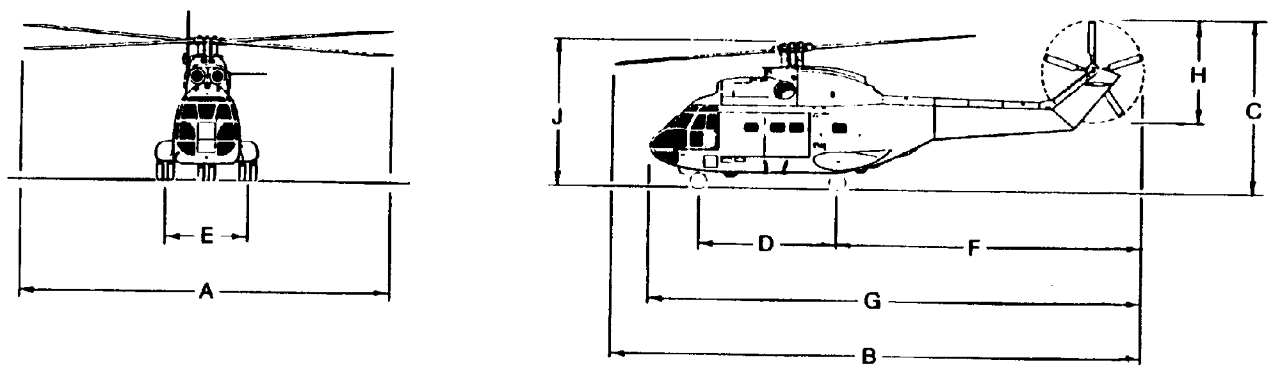


Figure C-112. Aerospatiale 330J, Puma

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	85	85	51.2	61.4	16.2	17.2	9.8	†	†	10.0	15.2

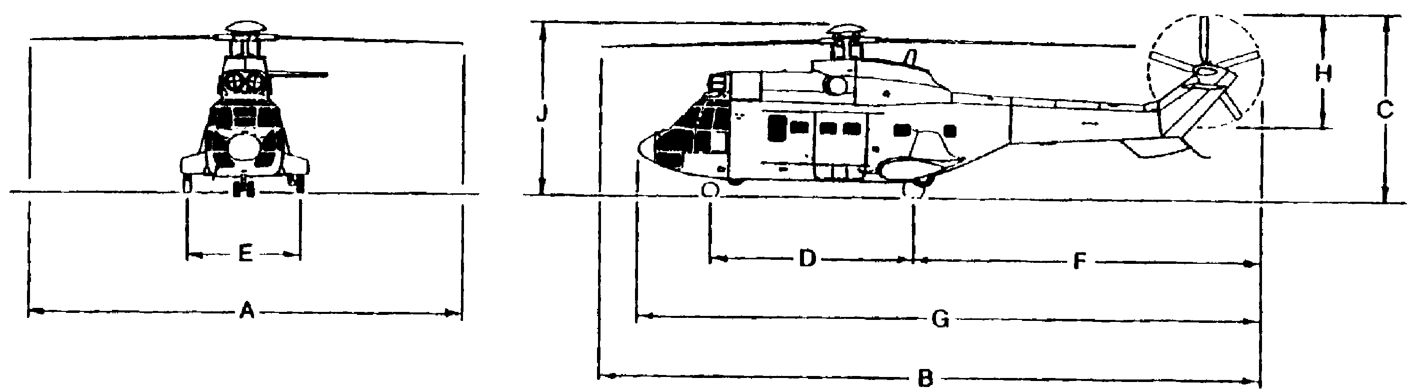


Figure C-113. Aerospatiale 332C/L, Super Puma

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	45.0	45.0	34.5	39.3	10.4	6.4	†	6.7	†	31.3	2.3*	8.9

* ENCLOSED TAIL ROTOR

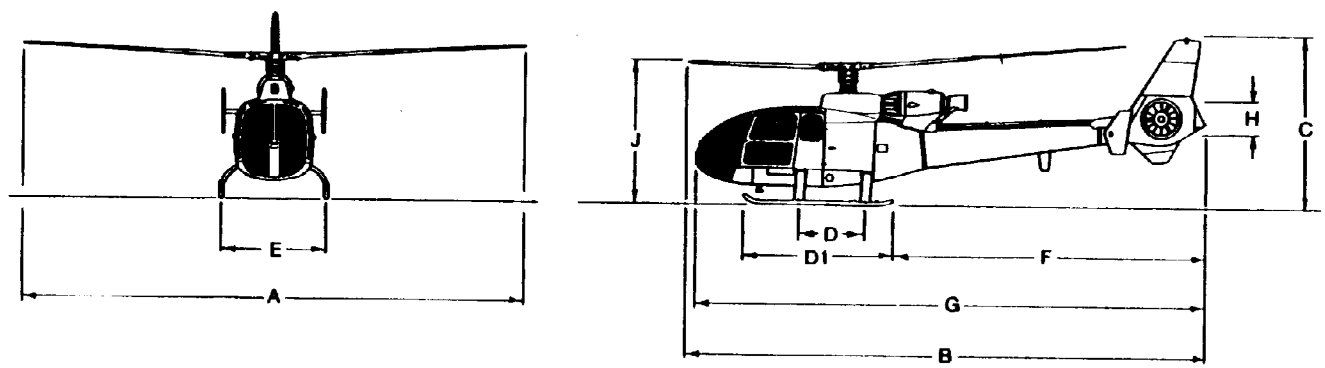


Figure C-114. Aerospatiale 341, Gazelle

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	43.0	43.0	35.1	42.6	10.3	4.7	†	7.2	†	35.8	6.1	†

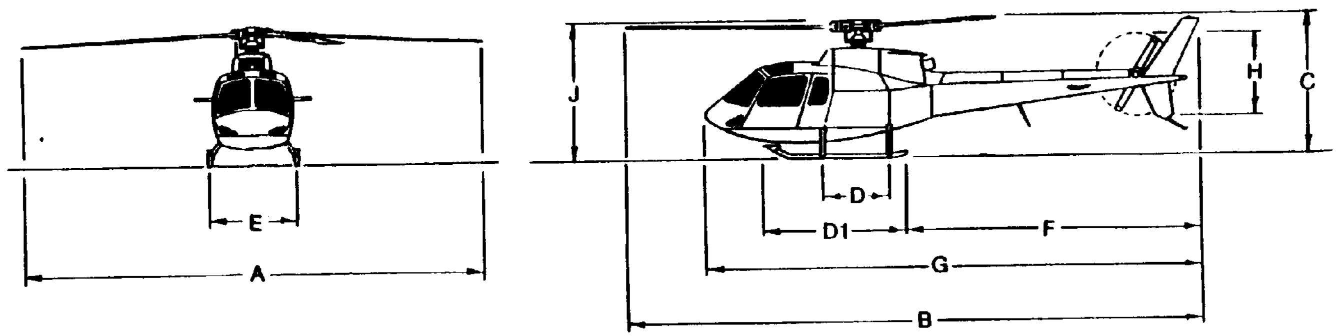


Figure C-115. Aerospatiale 350B/D, Astar

MODEL	MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
		FORWARD	AFT										
355E/F	3	43.0	43.0	35.1	42.6	10.6	4.5	†	6.6	†	35.8	6.1	†
355F1	3	43.0	43.0	35.1	42.6	10.6	4.5	†	7.1	†	35.8	6.1	†

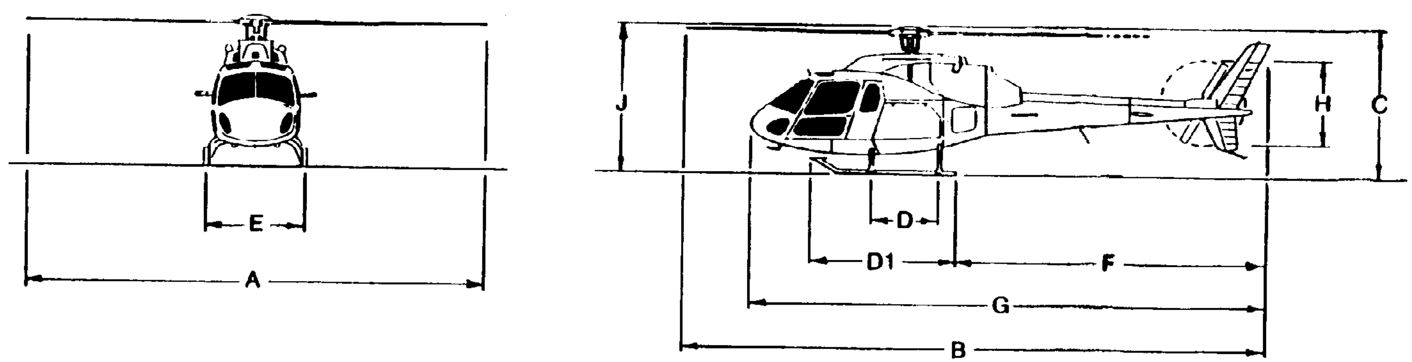


Figure C-116 Aerospatiale 355E/F/F1, Twinstar

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	73	73	37.7	43.3	11.5	23.7	6.4	†	36.0	3.0*	†

* ENCLOSED TAIL ROTOR.

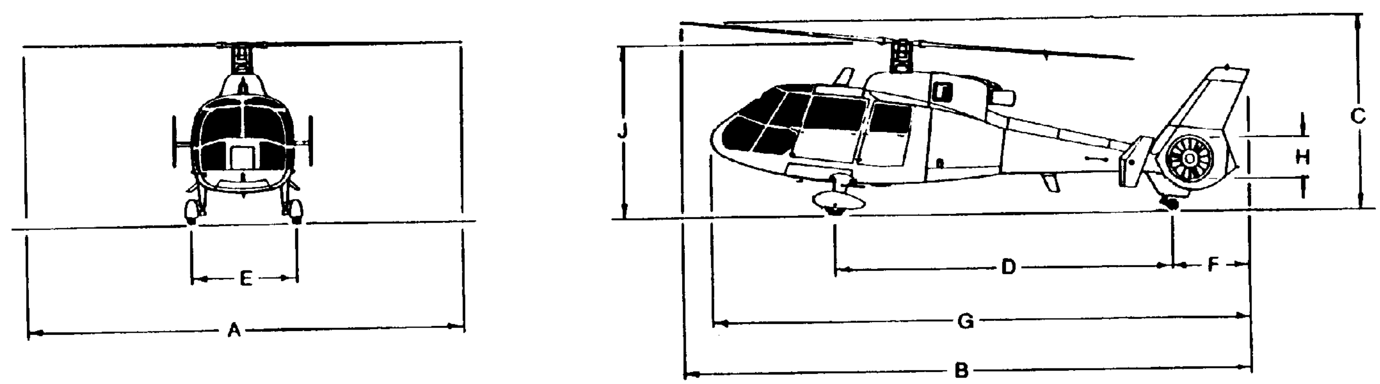


Figure C-117. Aerospatiale 360C, Dauphin

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	73	73	38.3	43.7	11.4	23.7	6.4	†	36.0	3.0*	†

* ENCLOSED TAIL ROTOR.

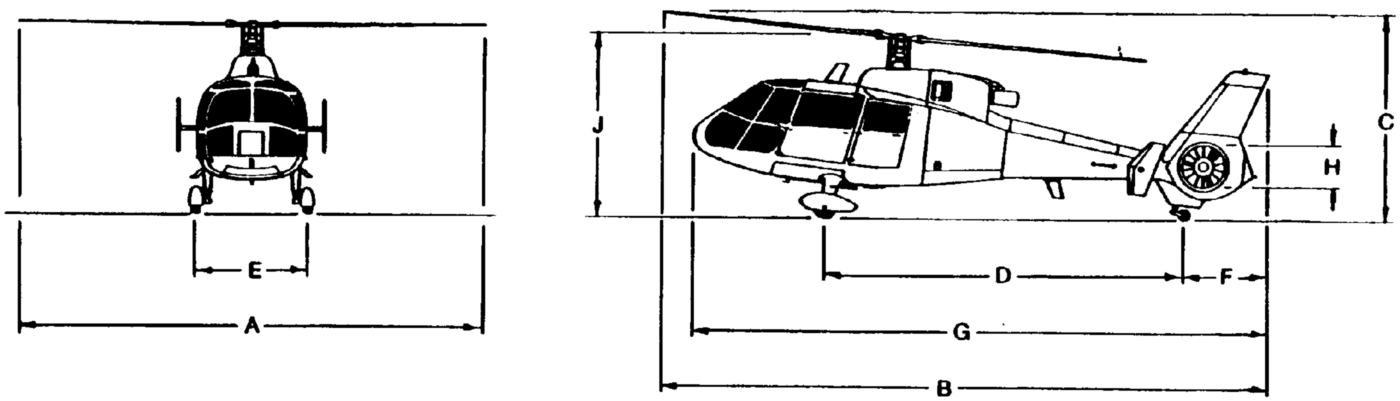


Figure C-118. Aerospatiale 365C, Dauphin 2

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	58	101	39.1	44.2	13.1	11.8	6.6	†	37.6	3.0*	11.5

* ENCLOSED TAIL ROTOR.

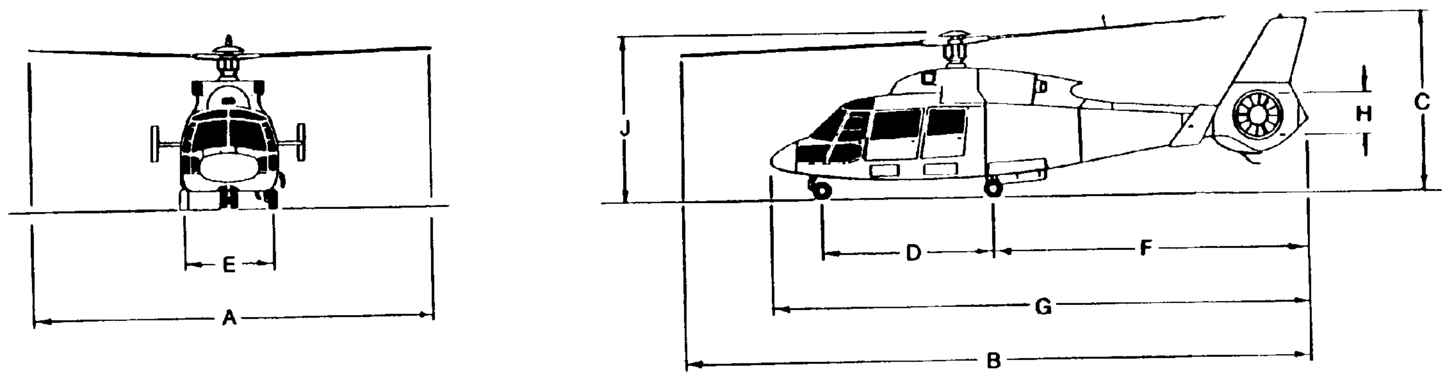


Figure C-119. Aerospatiale 365N, Dauphin 2

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	85	85	25.6	42.8	10.8	11.6	7.5	23.7	37.6	6.7	9.5

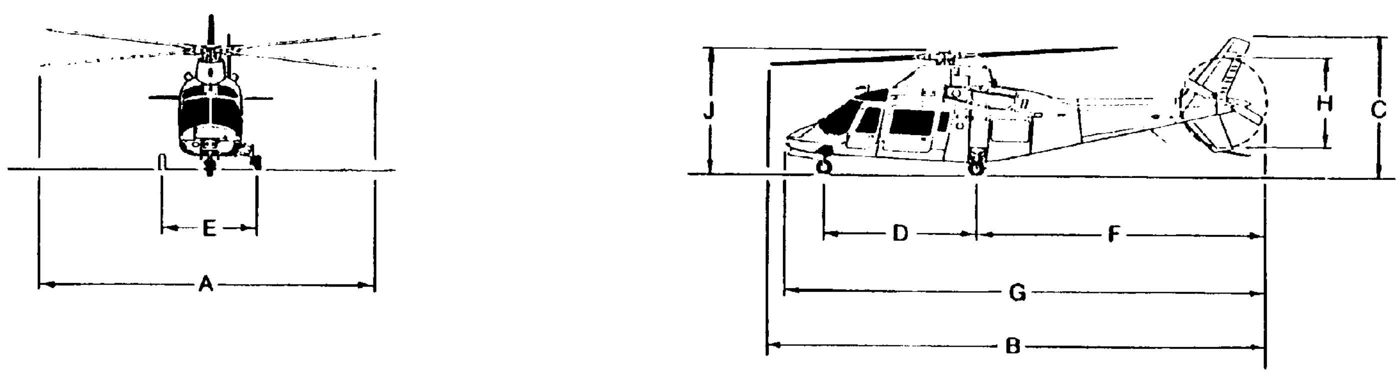


Figure C-120. Agusta 109A and 109A MkII

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	16.1	16.1	37.1	43.3	9.3	5.1	9.4	7.5	22.8	32.3	5.8	9.4

SILHOUETTES NOT AVAILABLE

Figure C-121. Bell 47G-3B (OH-13 and TH-13T), Sioux

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	37.1	43.6	9.3	†	9.9	7.5	†	†	5.8	†

SILHOUETTES NOT AVAILABLE

Figure C-122. Bell 47G-5A

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	24.3	25.0	44.0	53.0	14.8	7.6	12.1	8.4	29.8	42.7	8.5	12.7

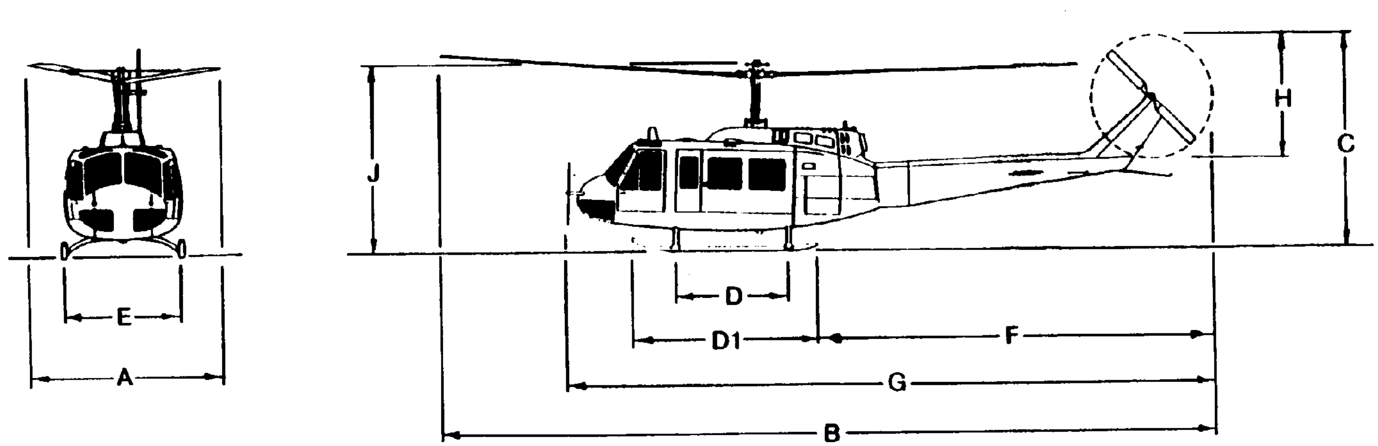


Figure C-123. Bell 204 (UH-1B/C/M), Iroquois

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	24.3	25.0	48.0	57.1	14.5	7.6	12.1	8.6	29.8	44.9	8.5	13.1

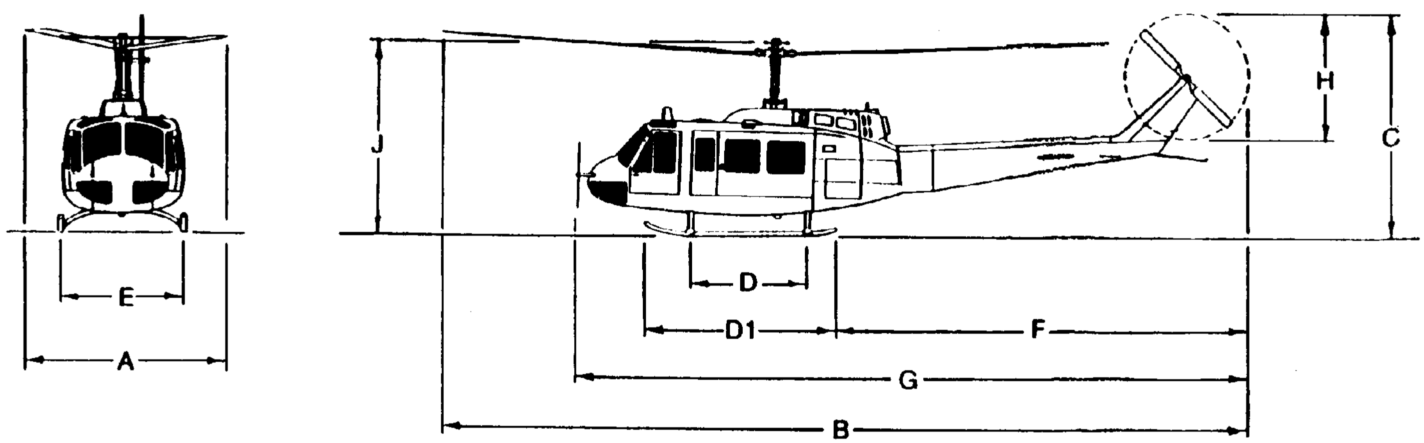


Figure C-124. Bell 205 (UH-1D/H), Iroquois

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	48.0	57.1	14.4	†	12.1	9.0	†	44.9	8.5	13.1

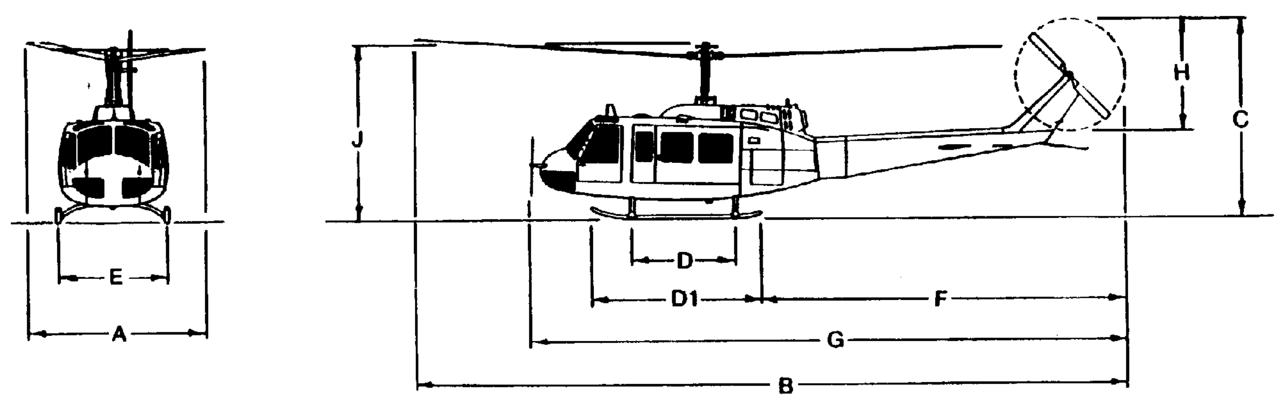


Figure C-125. Bell 205A-1

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	18.3	18.3	35.4	41.0	12.0	4.8	8.1	6.4	21.0	32.2	5.2	9.6

* HEIGHT OVER TAIL FIN, 8.2 FT.

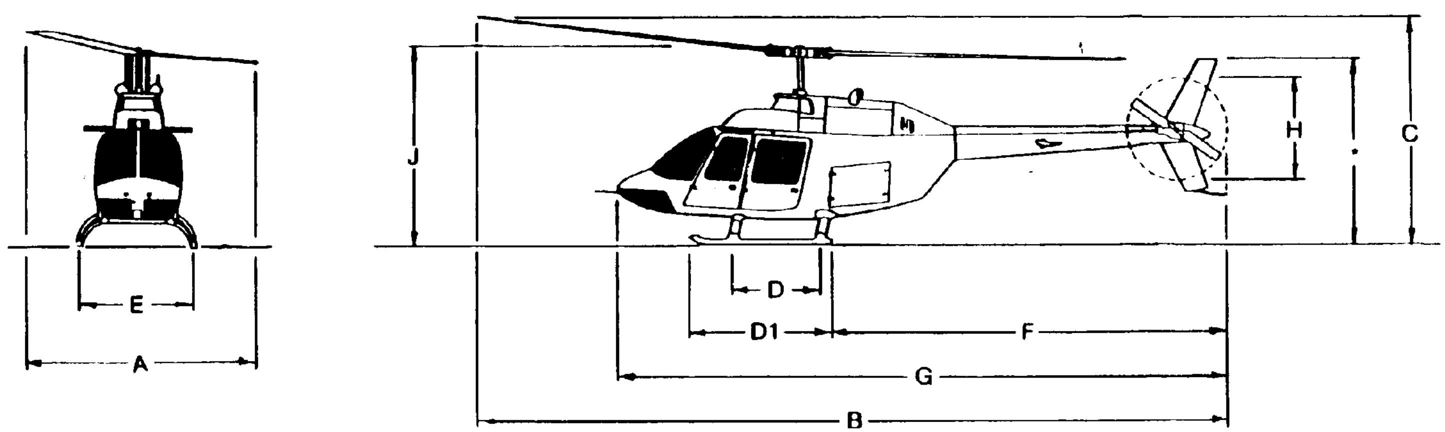


Figure C-126. Bell 206A (OH-58A/C), Kiowa

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	13.5	13.5	33.3	39.2	11.6	4.5	7.8	6.0	†	31.2	5.4	9.6

* HEIGHT OVER TAIL FIN, 8.3 FT.

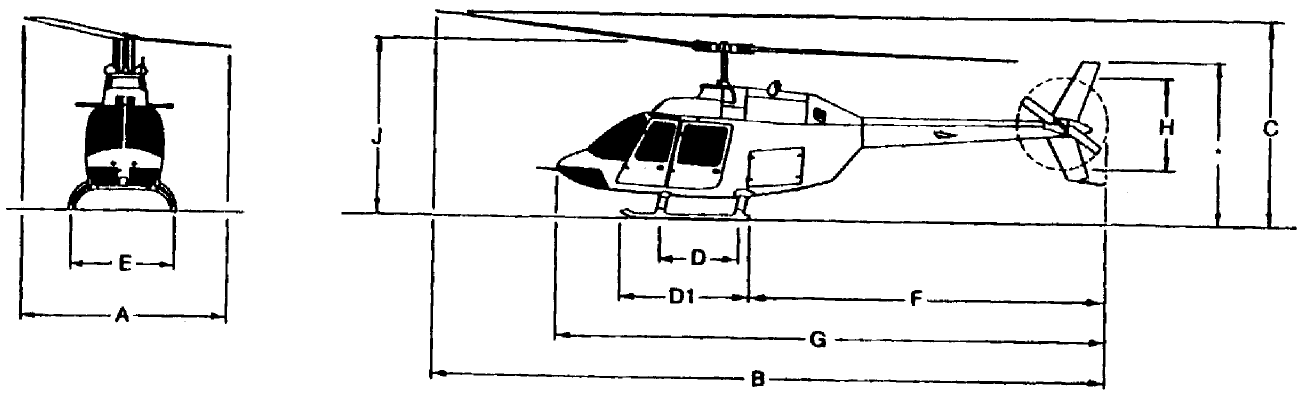


Figure C-127. Bell 206B, Jet Ranger 3

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	13.5	13.5	37.0	42.5	11.7	6.8	9.9	7.2	†	†	5.4	10.3

* HEIGHT OVER TAIL FIN, 9.5 FT.

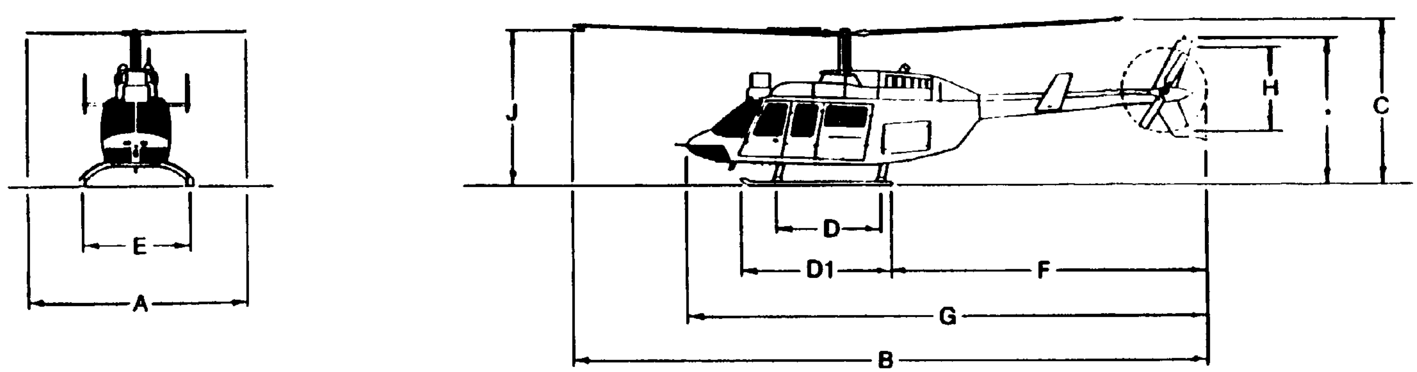


Figure C-128. Bell 206L-3, Long Ranger 3

MODEL	MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
		FORWARD	AFT										
AH-1G	2	26.4	26.4	44.0	52.9	13.5	5.9	11.0	7.3	28.5	46.0	8.5	13.4
AH-1S (PROD.)	2	26.4	26.4	44.0	53.0	13.5	5.9	11.0	7.3	28.5	46.0	8.5	13.4
AH-1S (ECAS)	2	26.4	26.4	44.0	53.1	13.5	5.9	11.0	7.0	28.5	46.0	8.5	13.4
AH-1S (MOD.)	2	26.4	26.4	44.0	53.1	13.5	5.9	11.0	7.0	28.5	46.0	8.5	13.4

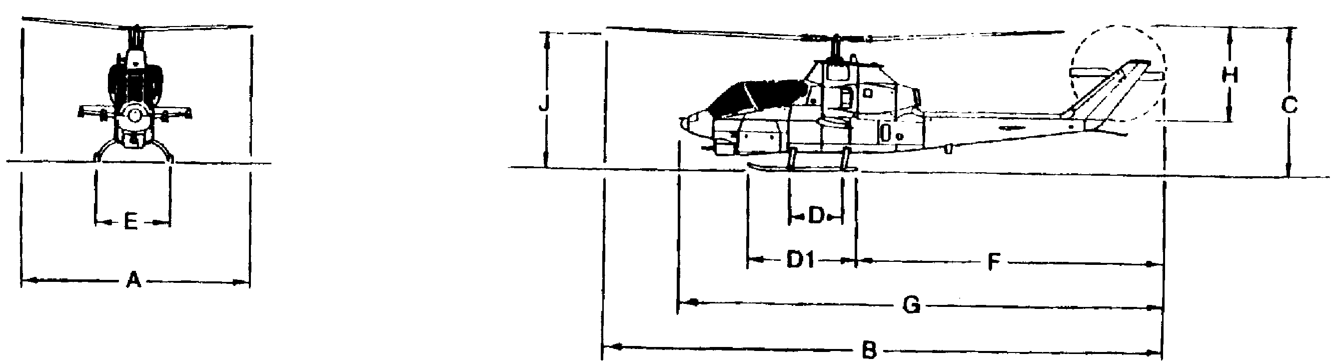


Figure C-129. Bell 209 (AH-1G), Cobra; [AH-1S (Production)], Cobra; [AH-1S (ECAS)], Upgun Cobra; [AH-1S (Modernized)], Mod. Cobra

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	24.0	24.0	48.0	57.3	14.4	7.6	12.1	8.7	29.8	45.9	8.6	12.8

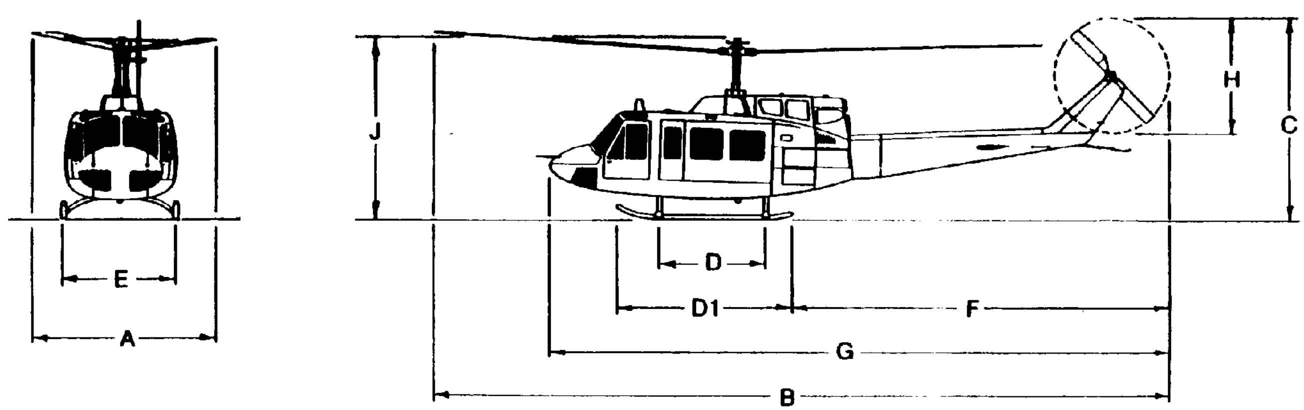


Figure C-130. Bell 212 (UH-1N), Twin Huey

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	24.0	24.0	48.0	57.3	13.0	7.6	12.1	8.3	†	†	8.6	†

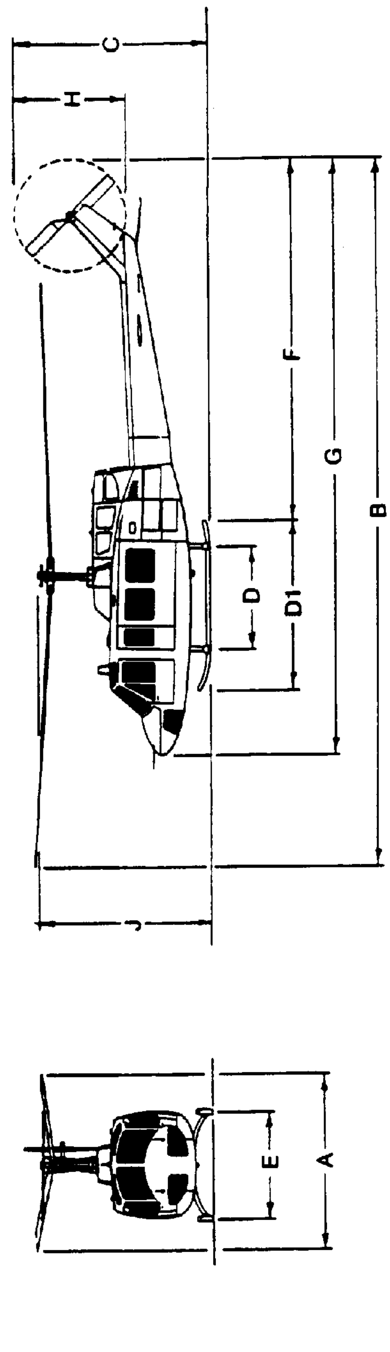


Figure C-131. Bell 212

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	50.0	60.4	13.4	†	12.1	8.6	†	†	9.6	†

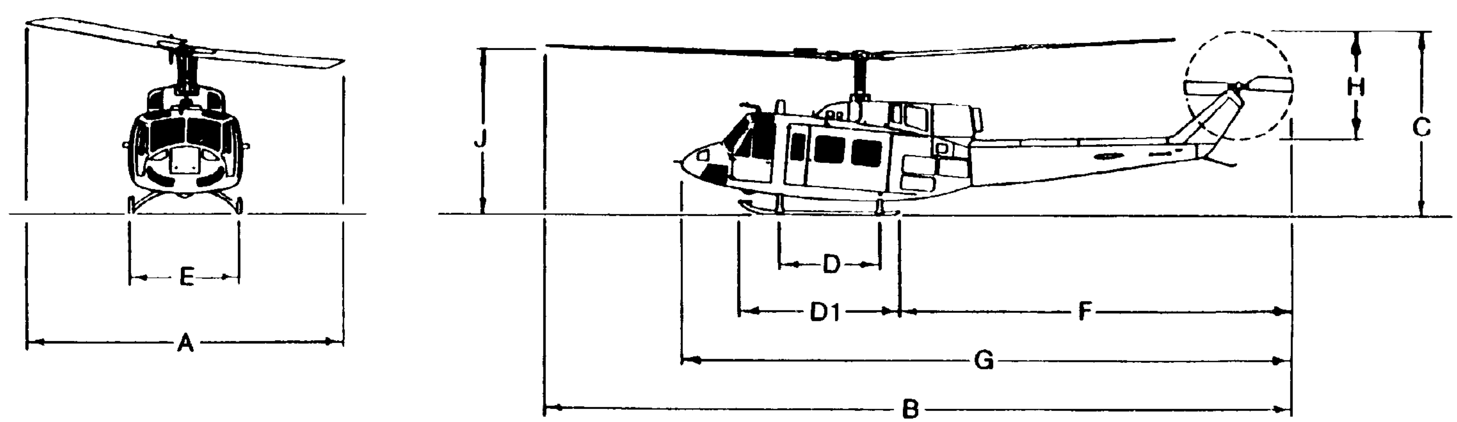


Figure C-132. Bell 214B, Big Lifter

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	52.0	62.2	13.2	8.1	†	8.3	†	†	9.7	†

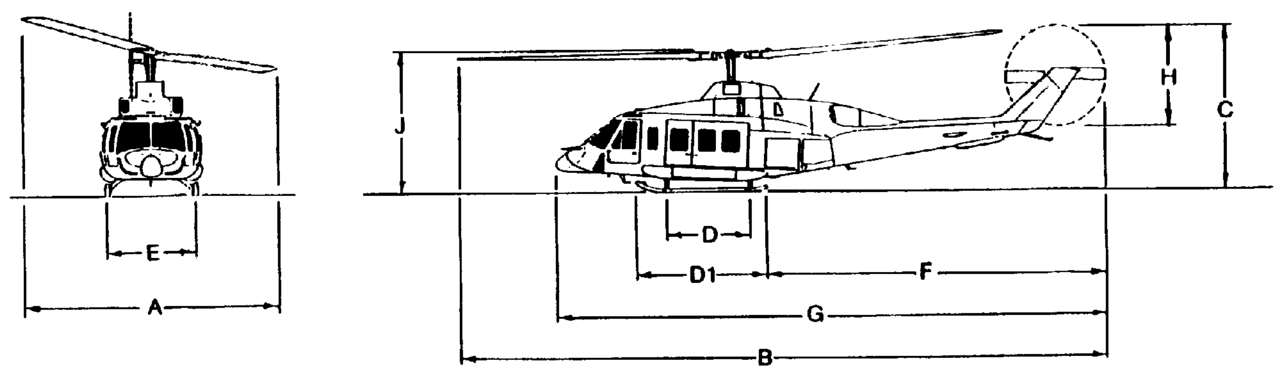


Figure C-133. Bell 214ST, Super Transport

MODEL	MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
		FORWARD GEAR	AFT GEAR									
222	2	60	75	39.8	47.5	11.0	12.2	9.1	†	36.0	6.5	†
222B	2	60	75	42.0	50.3	11.3	12.2	9.1	†	42.2	6.9	†

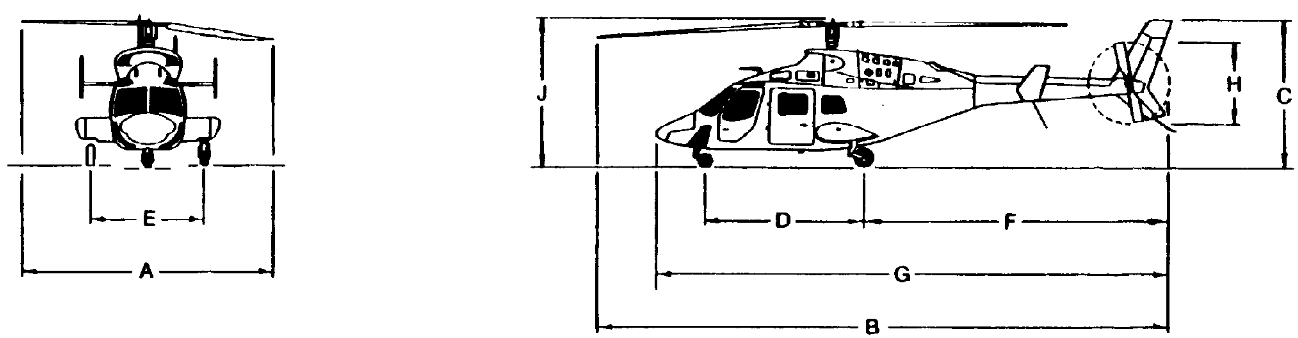


Figure C-134. Bell 222 and 222B

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	24.0	24.0	42.0	50.3	10.5	7.9	†	7.8	†	42.2	6.9	†

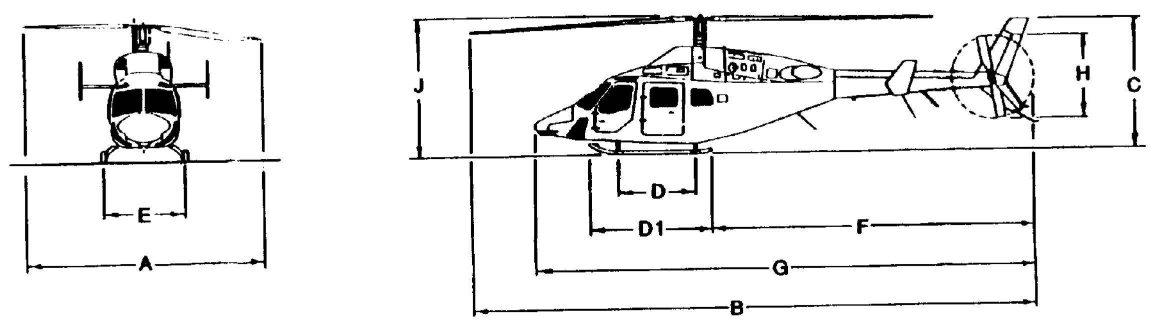


Figure C-135. Bell 222UT, Utility Twin

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
4	16.3	16.3	35.0	42.2	12.8	4.8	8.1	6.4	21.1	33.0	5.4	8.5

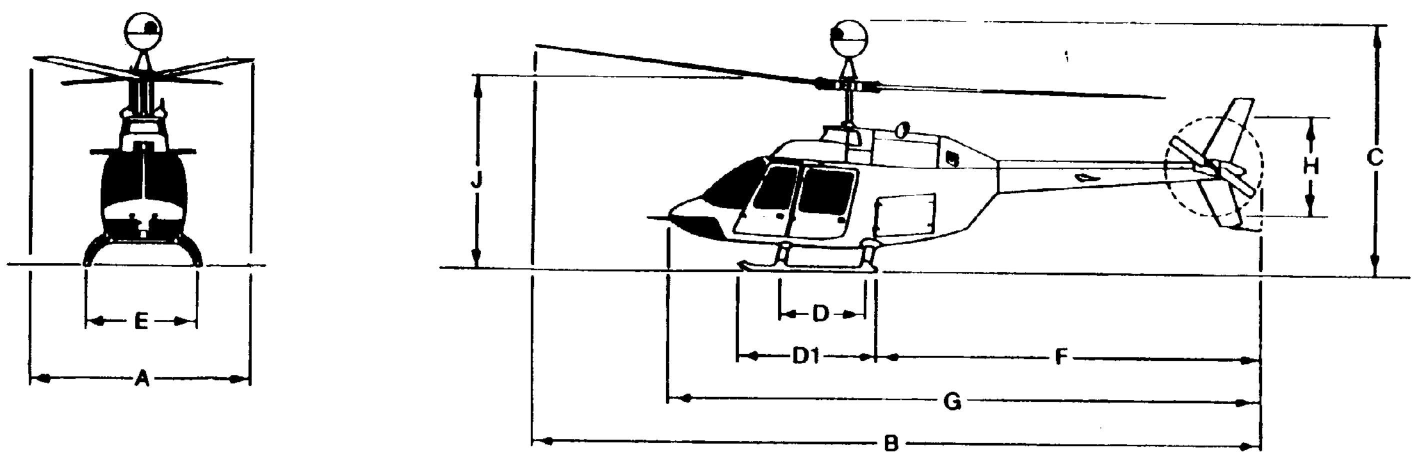


Figure C-136. Bell 406 AHIP (OH-58D), Kiowa

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
4	24.0	24.0	46.0	56.2	10.9	7.9	12.1	8.3	†	†	8.6	10.8

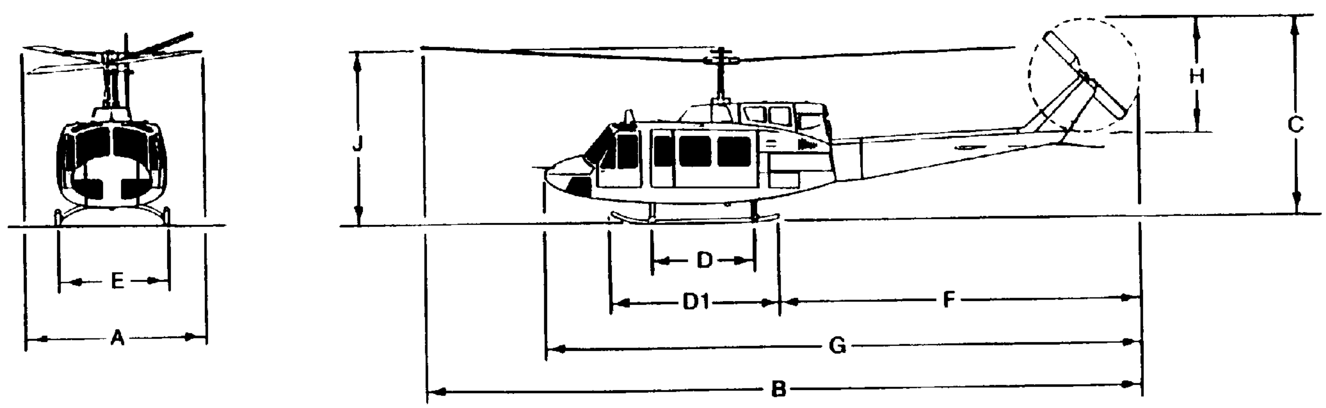


Figure C-137. Bell 412

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3*	†	†	84.6**	62.6	21.8	21.8	15.2	32.1	57.3	††	21.8

* THREE BLADES ON 2 ROTORS.

** EACH ROTOR DIAMETER IS 38.0 FT.

†† AIRCRAFT IS NOT EQUIPPED WITH VERTICAL TAIL ROTOR.

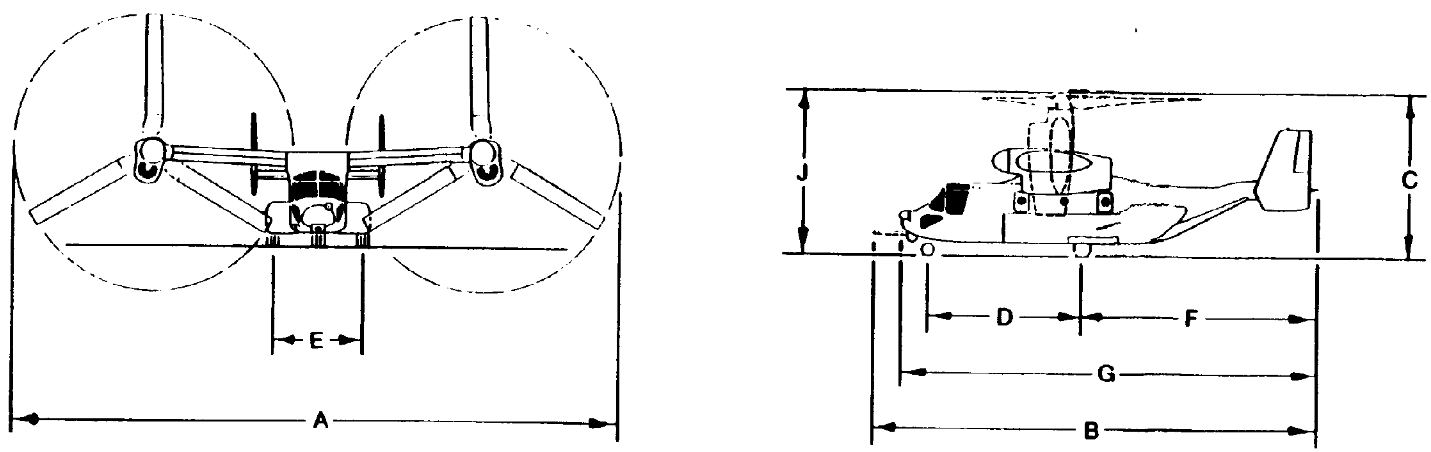


Figure C-138. Bell/Boeing 301 (V-22), Osprey

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3*	150	150	50.0	83.3	16.9	24.9	12.9	33.3	63.7	50.0**	15.0††

* THREE BLADES EACH ON 2 ROTORS.
** TAIL ROTOR IS HORIZONTAL.
†† DIMENSION FOR FORWARD ROTOR HEAD. AFT ROTOR HEAD DIMENSION IS 16.9 FT

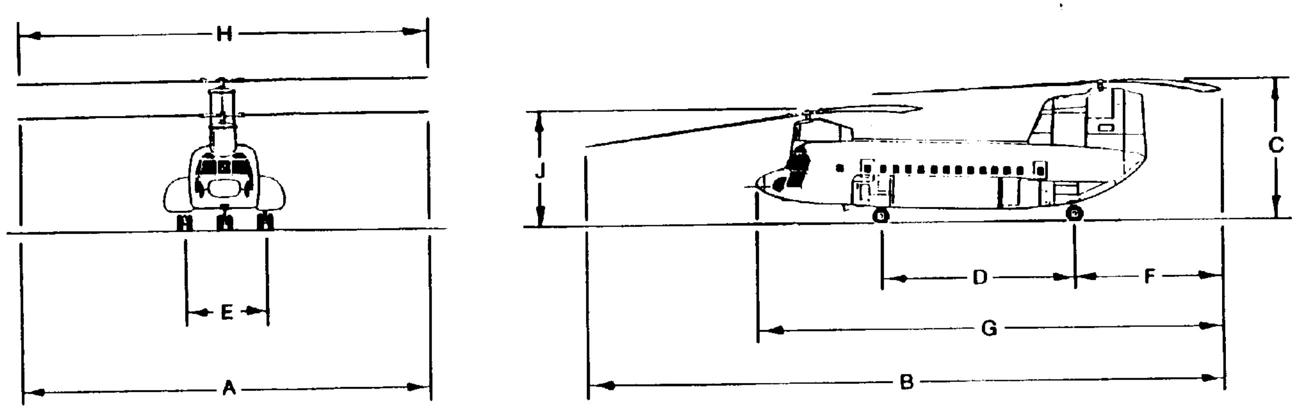


Figure C-139. Boeing 107-II

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3*	**	**	60.0	99.0	18.7	22.5	10.5	33.4	74.6	60.0††	15.3‡

* THREE BLADES EACH ON 2 ROTORS.
** TIRE PRESSURES FOR CH-47B, CH-47C, AND CH-47D ARE 67, 88, AND 124 PSI; RESPECTIVELY.
†† TAIL ROTOR IS HORIZONTAL.
‡ DIMENSION FOR FORWARD ROTOR HEAD. AFT ROTOR HEAD DIMENSION IS 18.7 FT.

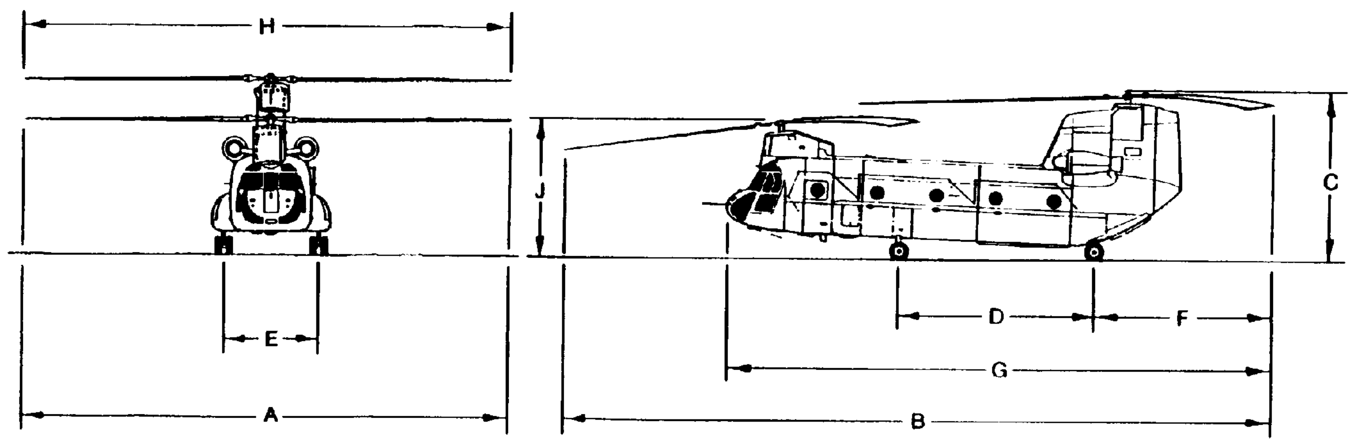


Figure C-140. Boeing 114 (CH-47B/C/D), Chinook

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3*	124	104	60.0	99.0	18.7	25.8	10.5	33.4	74.6	60.0**	15.3††

* THREE BLADES EACH ON 2 ROTORS.
** TAIL ROTOR IS HORIZONTAL.
†† DIMENSION FOR FORWARD ROTOR HEAD. AFT ROTOR HEAD DIMENSION IS 18.7 FT.

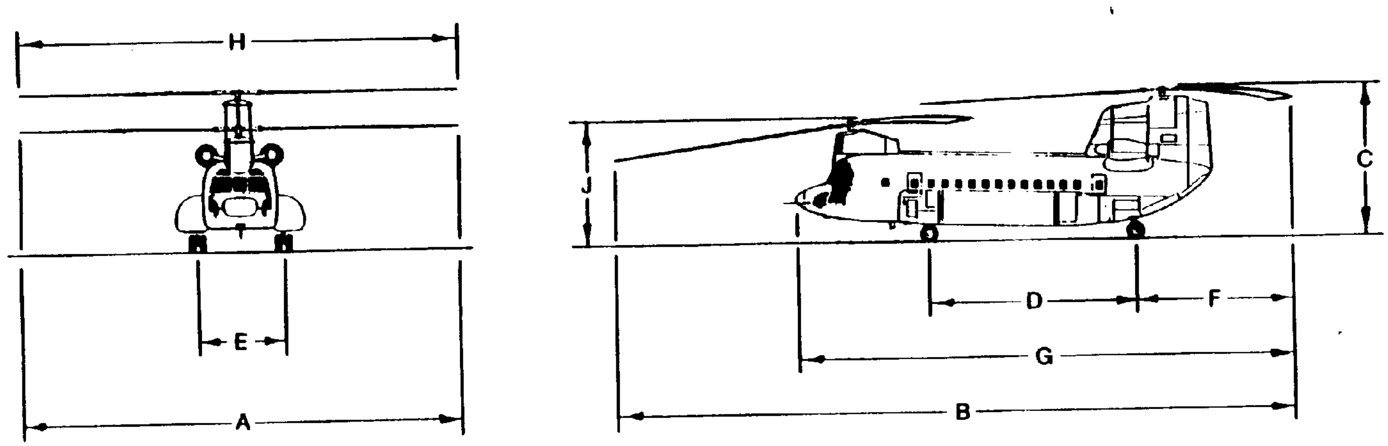


Figure C-141. Boeing 234 LR/ER/UT/MLR

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4*	†	†	49.7	83.3	19.6	32.7	11.4	30.4	66.4	49.7**	14.8††

* FOUR BLADES EACH ON 2 ROTORS.
** TAIL ROTOR IS HORIZONTAL.
†† DIMENSION FOR FORWARD ROTOR HEAD. AFT ROTOR HEAD DIMENSION IS 19.6 FT.

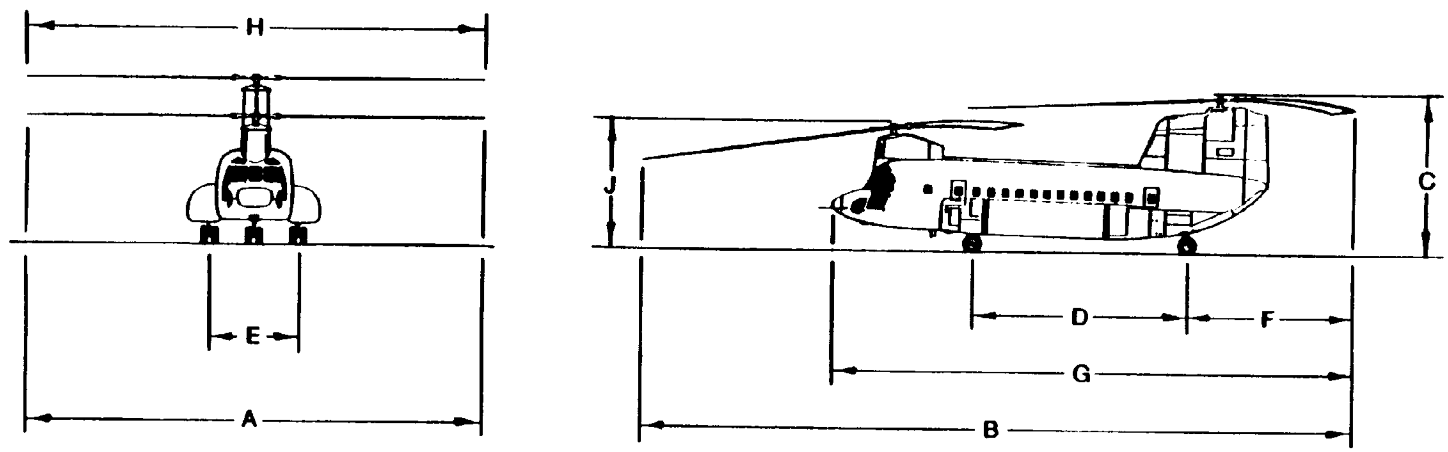


Figure C-142. Boeing 360

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
5	†	†	61.0	75.3	21.3	22.9	14.1	†	†	13.1	†

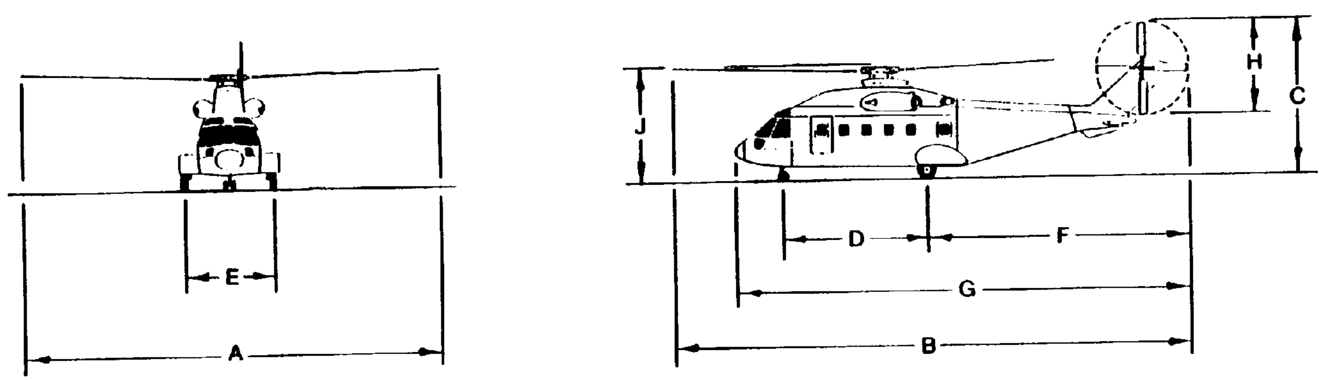


Figure C-143. E.H. Industries EH 101

MODEL	MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
		FORWARD	AFT										
280C 280F 280FX	3	†	†	32.0	29.3	9.0	†	8.0	7.4	†	28.7	4.7	9.0
F28C-2 F28F	3	†	†	32.0	29.3	9.0	†	8.0	7.4	†	28.1	4.7	9.0

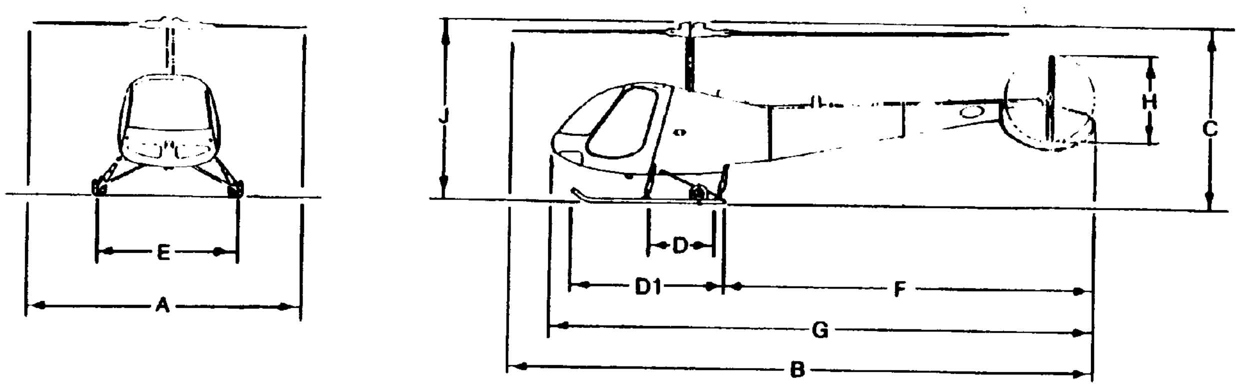


Figure C-144. Enstrom 280C, F28C-2, 280F, and 280FX; Shark and F28F; Falcon

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	†	†	23.8	28.0	6.8	†	†	5.7	†	†	4.3	†

SILHOUETTES NOT AVAILABLE

Figure C-145. Hynes H-2/with skid landing gear

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3	28	30	23.8	28.0	6.8	7.1	6.9	†	†	4.3	†

SILHOUETTES NOT AVAILABLE

Figure C-146. Hynes H-2/with wheel landing gear

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	†	†	28.5	32.9	6.0	†	†	5.7	†	†	4.3	†

SILHOUETTES NOT AVAILABLE

Figure C-147. Hynes H-5/with skid landing gear

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3	28	30	28.5	32.9	6.0	7.1	6.9	†	†	4.3	†

SILHOUETTES NOT AVAILABLE

Figure C-148. Hynes H-5/with wheel landing gear

MODEL	MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
		FORWARD	AFT										
BO 105 CB	4	19.5	19.5	32.3	38.9	12.5	8.3	8.9	8.2	20.5	31.2	6.2	9.8
BO 105 CBS/LS	4	19.5	19.5	32.3	38.9	12.5	8.3	8.9	8.2	20.5	32.0	6.2	9.8

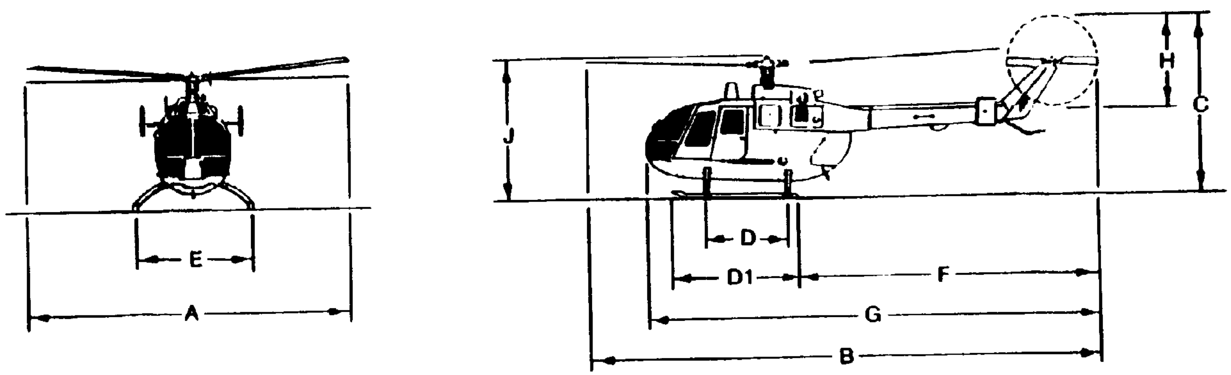


Figure C-149. MBB BO 105 CB/CBS/LS

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
4	31.8	31.8	36.1	42.7	12.6	6.2	10.1	7.9	21.4	35.4	6.4	11.0

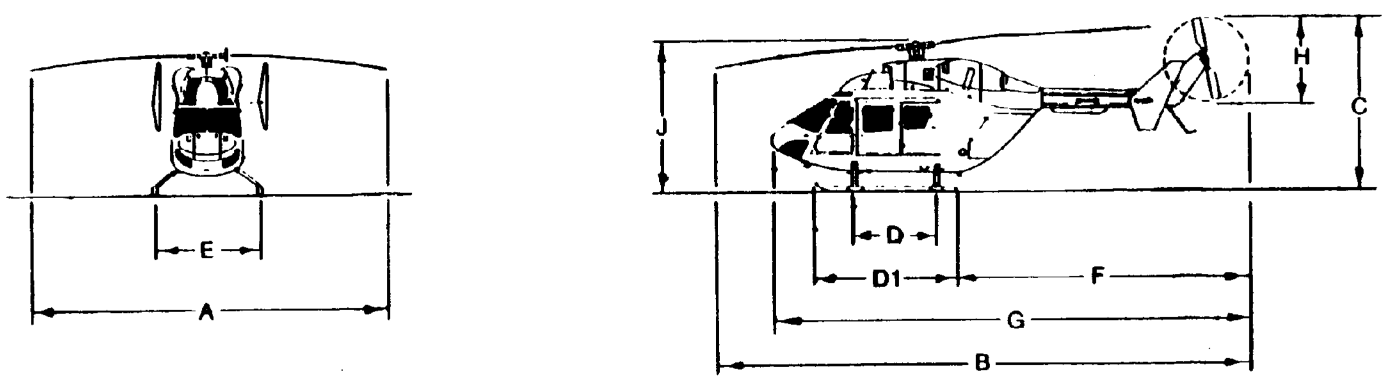


Figure C-150. MBB/Kawasaki BK 117

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	105	105	48.0	58.3	16.8	34.8	6.7	2.8	48.2	9.2	12.6

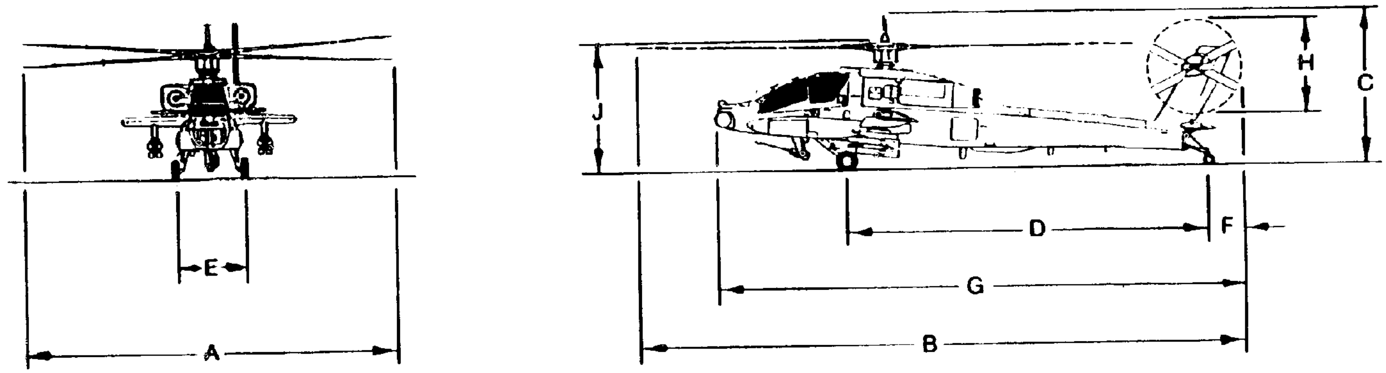


Figure C-151. McDonnell Douglas 77 (AH-64A), Apache

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
4	15.8	15.8	26.3	30.3	8.5	4.5	7.8	6.8	15.7	23.4	4.3	8.3

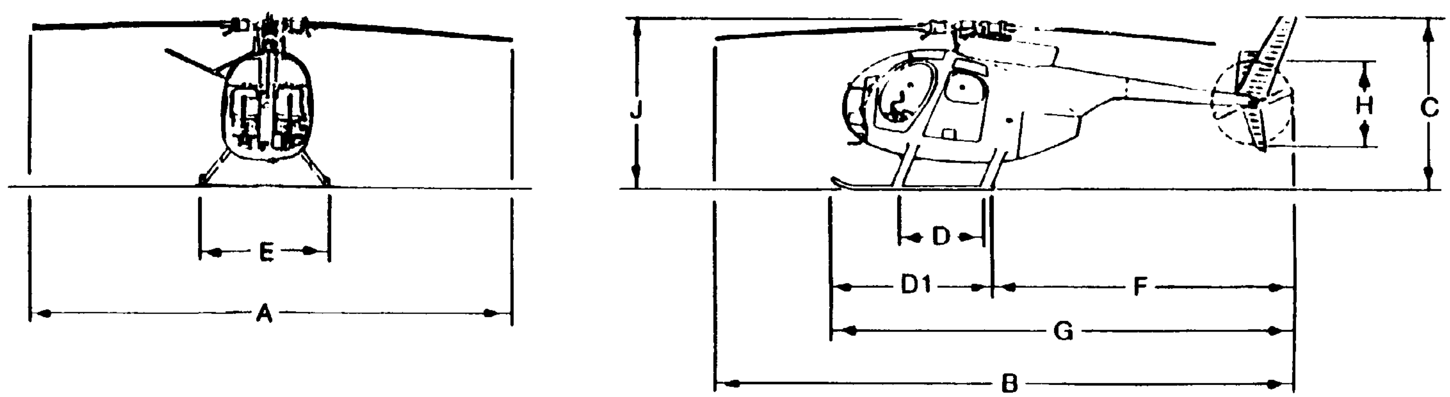


Figure C-152. McDonnell Douglas 500 (OH-6A), Cayuse

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
5	15.8	23.1	26.4	30.8	8.4	4.5	7.8	6.8	15.8	23.6	4.6	8.4

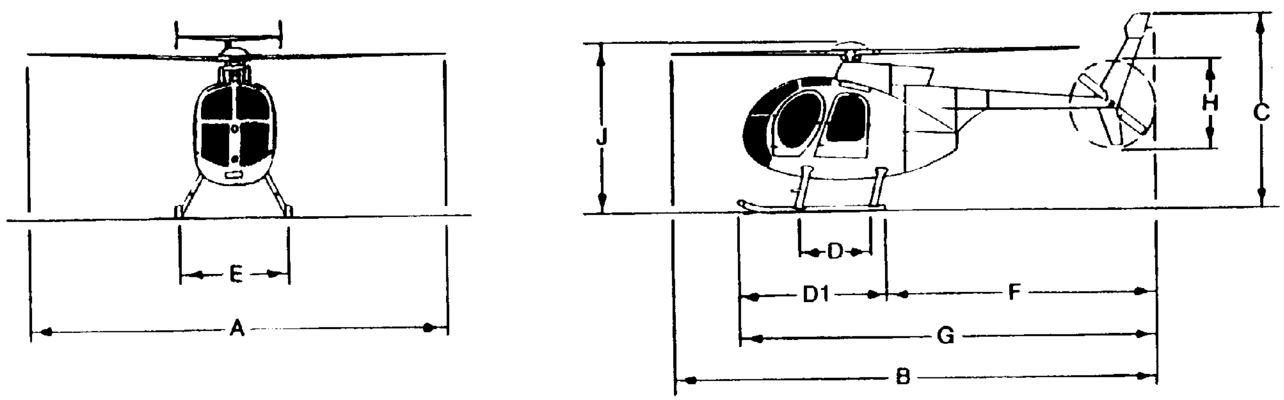


Figure C-153. McDonnell Douglas 500D

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
5	15.8	23.1	27.4	32.1	8.2	4.5	7.8	6.9	16.5	25.6	4.8	8.4

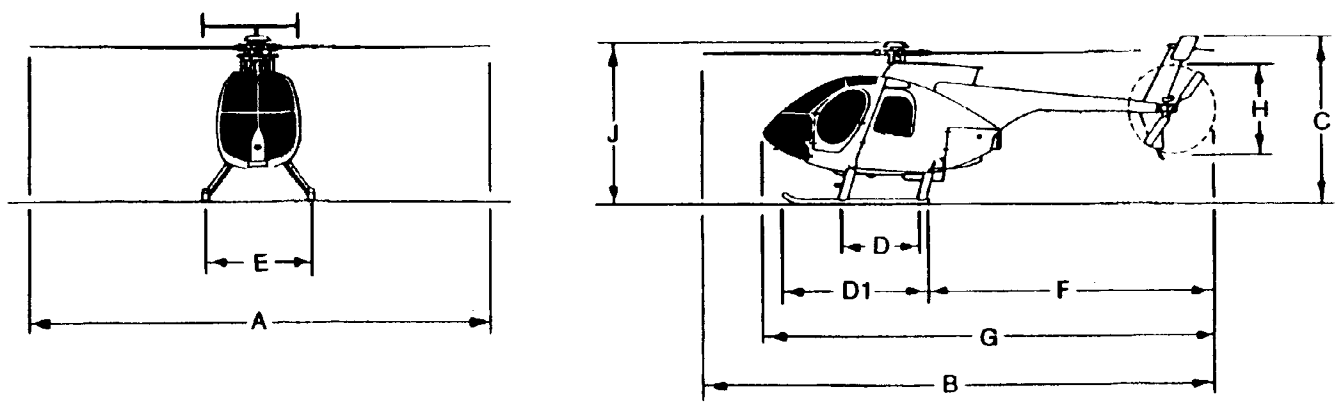


Figure C-154. McDonnell Douglas 530F

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	3.8	3.8	25.2	28.8	8.8	4.2	7.8	6.3	14.0	21.8	3.5	8.8

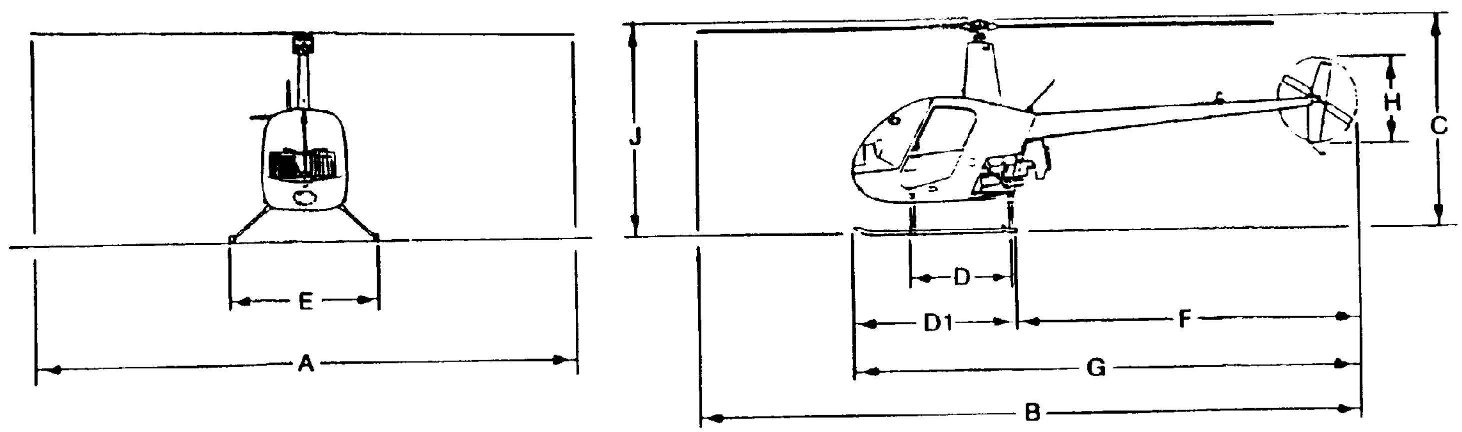


Figure C-155. Robinson R22

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	35.4	39.8	9.3	†	†	7.3	†	†	6.0	9.3

SILHOUETTES NOT AVAILABLE

Figure C-156. Rogerson Hiller RH-1100

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
2	†	†	35.4	40.8	10.1	†	8.3	7.5	†	†	5.5	10.1

SILHOUETTES NOT AVAILABLE

Figure C-157. Rogerson Hiller UH-12E/E4/ET/E4T

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN²		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	4.2	4.2	27.4	28.3	8.3	3.6	8.0	6.3	14.1	22.3	3.8	8.3

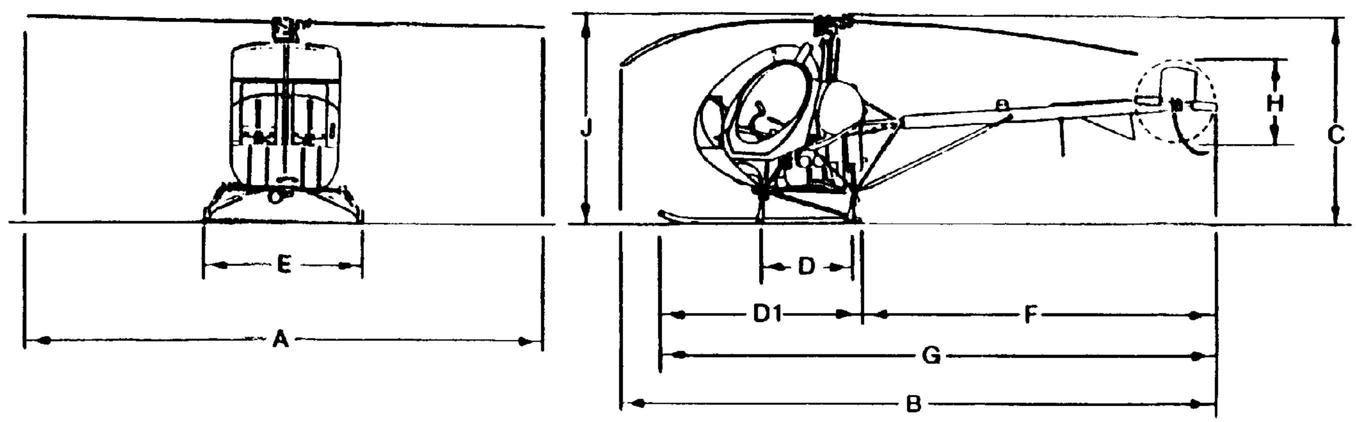


Figure C-158. Schweizer 269A (TH-55A), Osage

MAIN ROTOR BLADES, NO.	CONTACT AREA, IN^2		A	B	C	D	D1	E	F	G	H	J
	FORWARD	AFT										
3	4.2	4.2	26.8	30.8	8.7	3.8	8.2	6.5	13.9	23.0	4.3	8.7

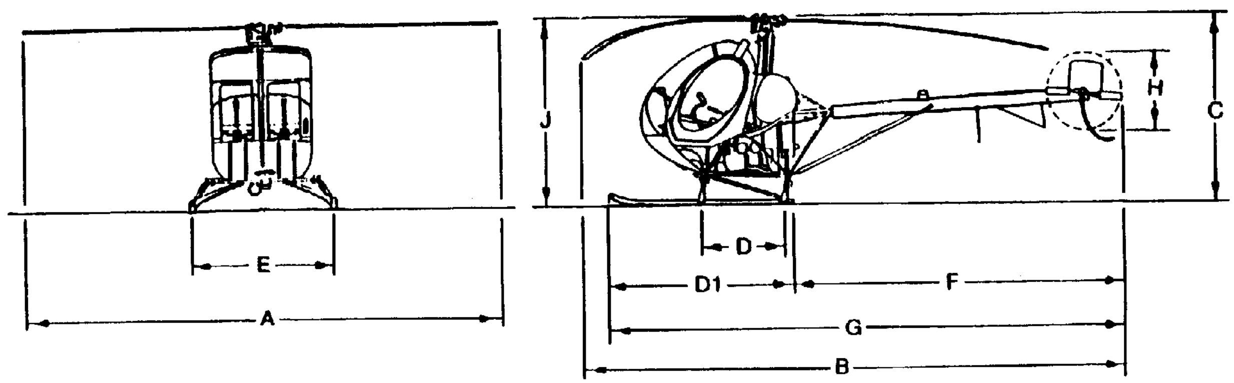


Figure C-159. Schweizer 300C

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	42	†	56.0	65.8	15.9	28.3	12.0	†	51.1	9.5	14.3

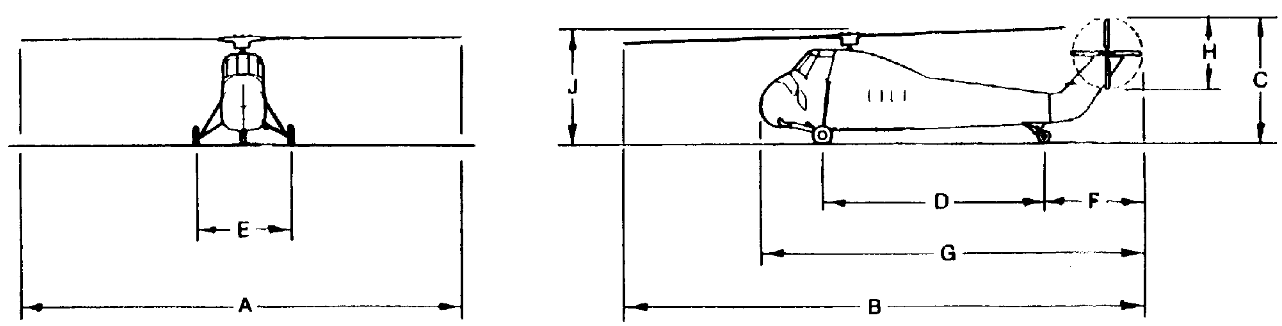


Figure C-160. Sikorsky S-58T

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
5	70	†	62.0	72.8	18.9	23.5	13.0	17.4	†	10.3	15.5

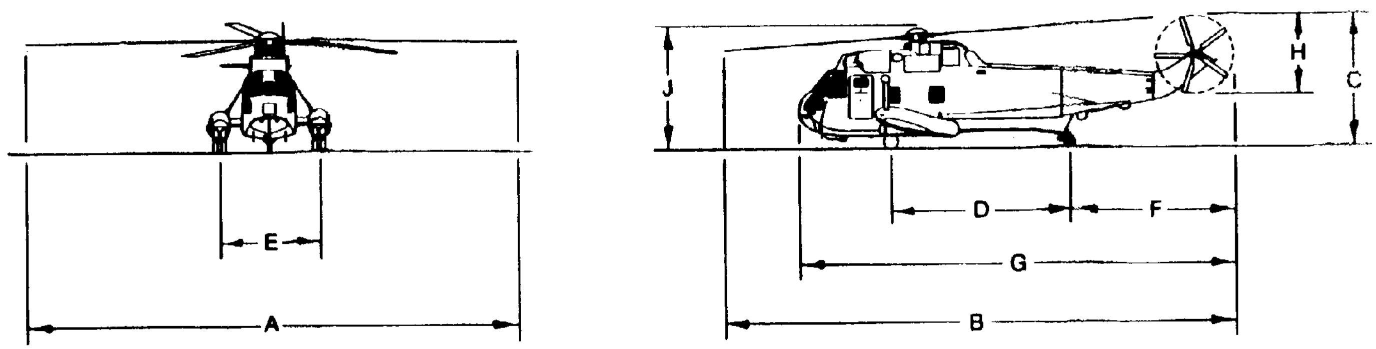


Figure C-161. Sikorsky S-61N

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
3	70	70	53.0	62.3	16.0	17.8	12.2	†	49.0	8.8	14.2

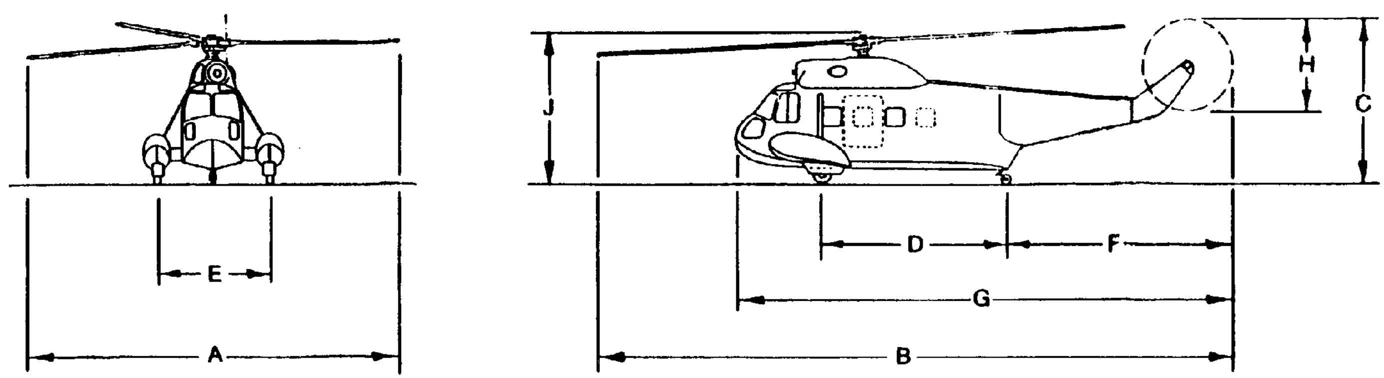


Figure C-162. Sikorsky S-62

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
6	100	95	72.0	88.5	25.4	24.4	19.8	46.1	76.3	16.0	18.6

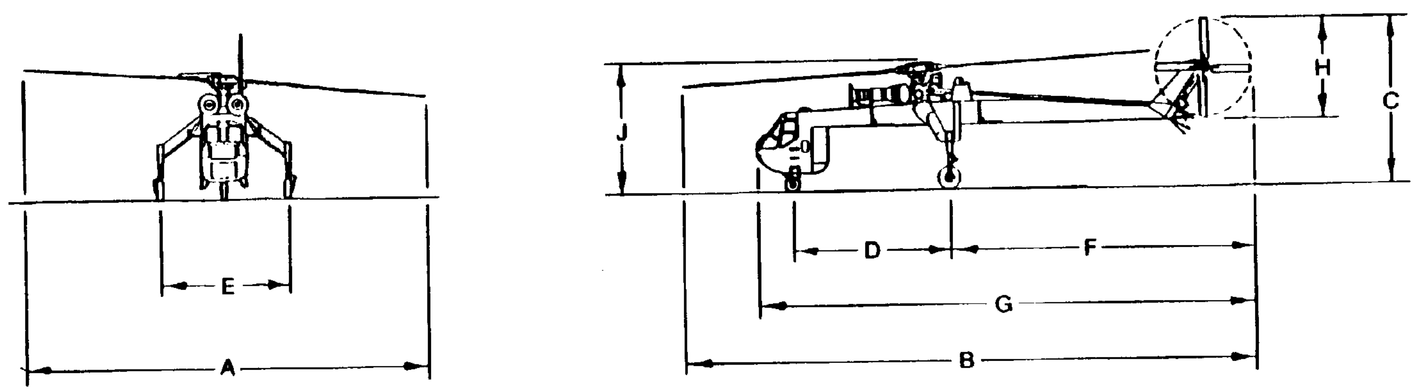


Figure C-163. Sikorsky S-64 (CH-54A), Tarhe

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
6	95	95	72.3	88.3	24.9	27.3	13.0	43.9	74.2	16.0	17.2

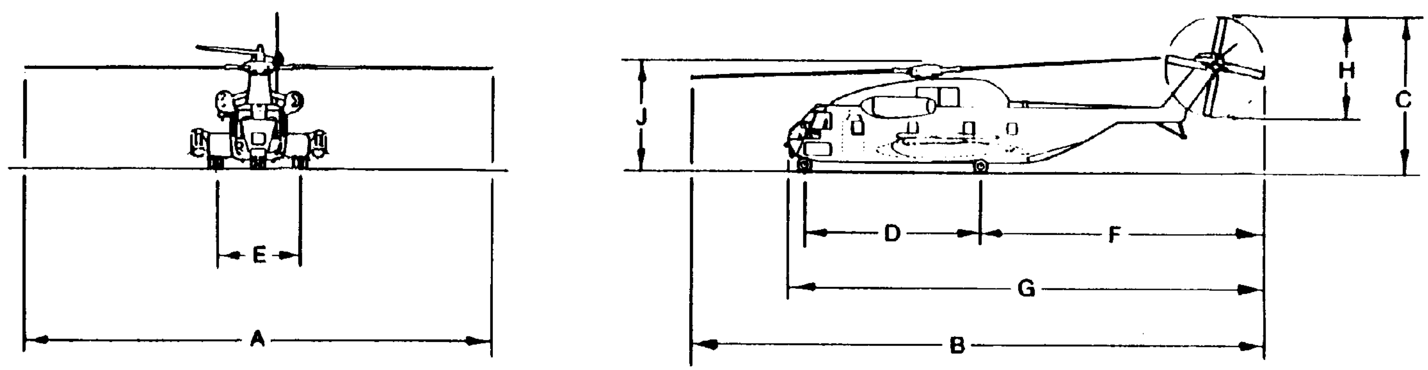


Figure C-164. Sikorsky S-65A (CH-53C and HH-53C), Super Jolly

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	140	95	53.7	64.8	17.5	29.0	8.8	12.7	53.0	11.0	12.4

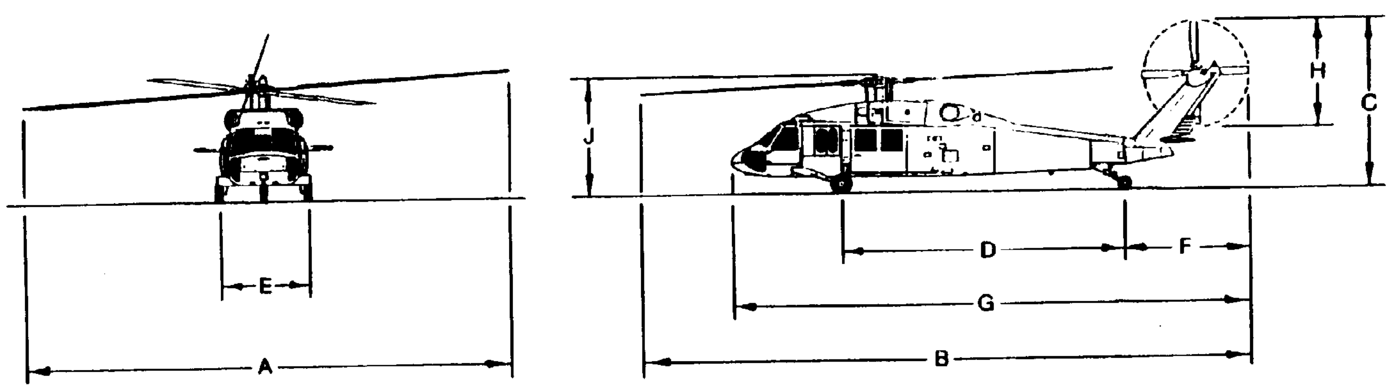


Figure C-165. Sikorsky S-70 (HH-60A, Night Hawk and UH-60A, Black Hawk)

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	140	95	53.7	64.8	16.8	29.0	8.8	12.7	53.0	11.0	12.4

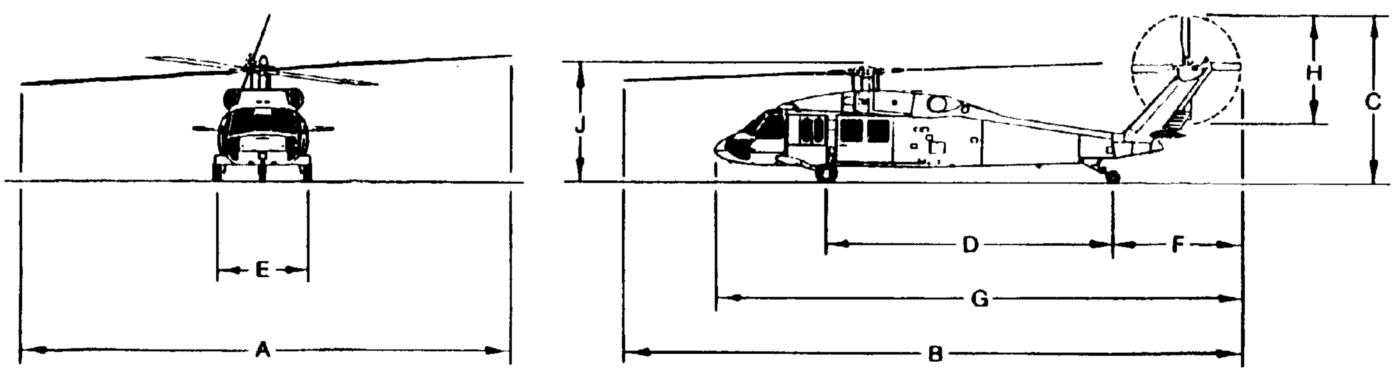


Figure C-166. Sikorsky S-70C

MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
	FORWARD GEAR	AFT GEAR									
4	135	165	44.0	52.5	14.5	16.4	8.0	22.1	46.1	8.0	11.8

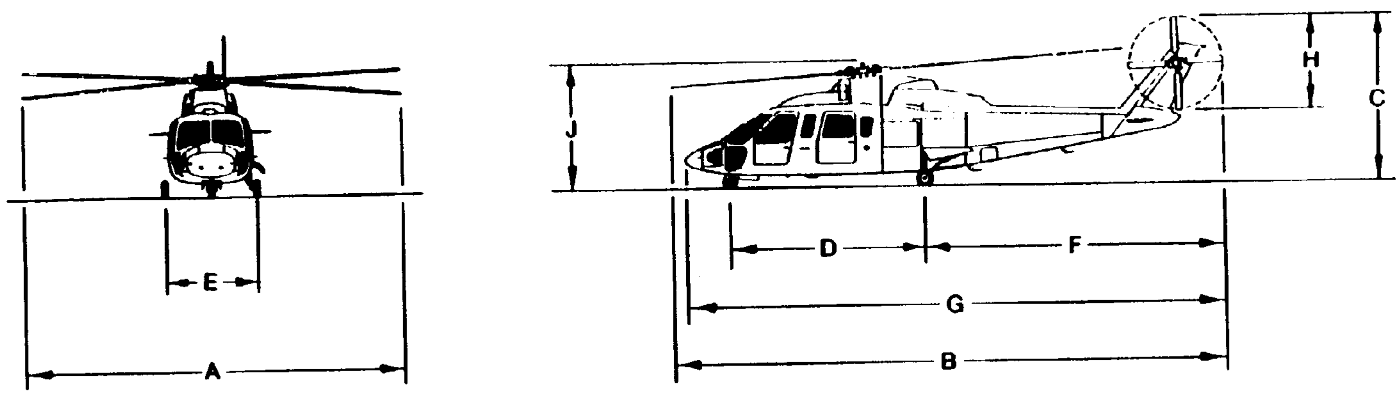


Figure C-167. Sikorsky S-76A/B

MODEL	MAIN ROTOR BLADES, NO.	MAXIMUM TIRE PRESSURE, PSI		A	B	C	D	E	F	G	H	J
		FORWARD GEAR	AFT GEAR									
30-100-60	4	55	68	43.7	52.1	15.5	17.9	10.1	†	52.1	8.0	†
30-200	4	55	68	43.7	52.1	15.4	17.9	10.1	†	52.1	8.0	†
30-300	5	†	†	42.5	52.1	16.3	17.8	9.3	†	52.1	9.0	†

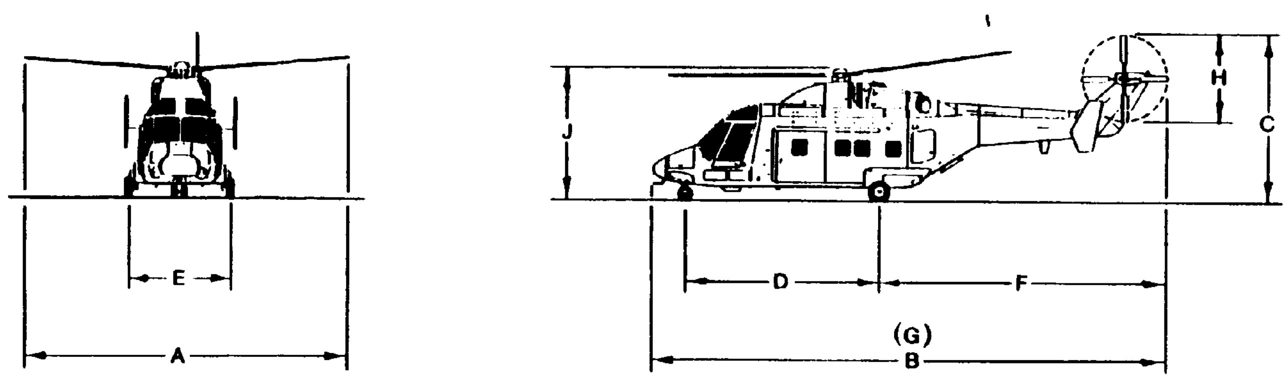


Figure C-168. Westland 30-100-60, 30-200 and 30-300

DESIGN OF U.S. ARMY AIRFIELD AIRCRAFT
MOORING AND GROUNDING POINTS FOR ROTARY WING AIRCRAFT

DRAFT GUIDE SPECIFICATION FOR MOORING AND GROUNDING POINTS FOR ROTARY WING AIRCRAFT AT ARMY INSTALLATIONS

****
NOTE: This guide specification covers requirements for U S Army projects requiring mooring and grounding points for rotary wing aircraft parking aprons and pads. This guide specification is to be used in the preparation of project specifications in accordance with ETL 1110-3-340.
****

PART 1 GENERAL

1.1 SUMMARY (Not Applicable)

1.2 REFERENCES

****
NOTE: Issue (date) of references included in project specifications should be checked to provide the most current version.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36	(1989) Structural Steel
ASTM A 436	(1984) Austenitic Gray Iron Castings
ASTM A 615	(1987) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616	(1987) Rail-steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617	(1987) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM B 8 (1986)	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B 371	(1984a) Copper-Zinc-Silicon Alloy Rod
ASTM C 94	(1990) Standard Specification for Ready Mix Concrete

AMERICAN WELDING SOCIETY (AWS)

AWS Dl.l	(1988) Structural Welding Code - Steel
AWS D1.4	(1979) Structural Welding Code - Reinforcing steel

UNDERWRITERS LABORATORIES (UL)

UL 467	(Nov 22, 1984; 6th Ed; Rev thru Nov 14, 1986) Grounding and Bonding Equipment

U.S. ARMY CORPS OF ENGINEERS, WATERWAYS EXPERIMENT STATION (CEWES)

CEWES CRD C-300	(1988) Handbook for Concrete and Cement: Membrane-Forming Compounds for Curing Concrete

1.3 SUBMITTALS

****
NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.
****

The following shall be submitted in accordance with Section SUBMITTALS:

****
If concrete is supplied by another specification section, a certificate of compliance should not be required here. Edit the following paragraph accordingly.
****

SD-76, Certificates of Compliance

Manufacturer*s certificates attesting that the mooring devices, grounding rods and concrete meet the specified requirements.

SD-90, As-Built Drawings

Drawings that provide current factual information including deviations from, and amendments to the drawings and changes in the work, concealed and visible.

****
The intent of this specification is to provide mooring points with resistance to ground of no more than 10,000 ohms. The items specified will provide that if the resistance of the surrounding soil or rock is less than 2,000,000 ohm-centimeters.
****

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General Requirements

No combination of materials shall be used that forms an electrolytic couple of such nature the corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals.

2.1.2 Mooring Devices

Mooring devices shall be cast in ductile iron 80-55-06 conforming to ASTM A 436. The device shall be as shown in the contract drawings. The contractor shall submit certificates of compliance on the devices.

2.1.3 Grounding Rods

Grounding rods shall conform to UL 467 and shall be made of copper-clad steel. The rods shall not be less than 5/8 inch in diameter and not less than 6 feet long, pointed at the bottom end and threaded with a 5/8 inch diameter American Standard Rolled thread at the top for attachment to the mooring device. The copper cladding shall conform to the applicable requirements of ASTM B 371 (Copper Alloy UNS No*s. c 69400, c 69430, c 69440 or c 69450). The copper cladding shall not be less than 0.010 inches thick at any point and shall comply with adherence requirements in paragraph 10.7 and the banding requirements in paragraph 10.8 of UL 467. The copper-clad steel rods shall conform to ASTM A 36 steel. The contractor shall submit certificates of compliance on the grounding rods.

2.1.4 Copper Conductors

Copper conductors shall be bare # 4 copper wire conforming to ASTM B 8. The contractor shall submit certificates of compliance on the copper conductors.

****
NOTE: Designer should edit the following paragraph to provide this section with concrete.
****

2.1.5 Concrete

****
NOTE: ASTM C 94 is set up to use Type I cement. If other types of cement are required because of site conditions, the designer should specify the proper cement type. The 6000 psi compressive strength concrete is required f or drilled piers and f or mooring point installation is existing rigid pavements. New rigid pavement with flexural strength of 500 psi or greater should be adequate for mooring point installation.
****

Concrete shall be in accordance with (Section; Concrete Pavements for Roads and Airfields] (ASTM C 94). The concrete shall be air entrained and have a minimum compressive strength of 6000 psi. The concrete shall have the following properties: Nominal maximum aggregate size of 1 inch, air content of 6%, and a maximum slump of 2 inches. The contractor shall submit certificates of compliance of the concrete mix.

2.1.6 Reinforcing Steel

Reinforcing steel shall conform to (ASTM A 615) (ASTM A 616] [ASTM A 617) Grade 36. Steel shall be welded into cages in accordance with AWS Dl.4 and inserted securely in the piers, in position and alignment, as shown, prior to concrete placement. The contractor shall submit certificates of compliance of the reinforcing steel.

PART 3 EXECUTION

****
Note: Types of mooring point installations not needed should be edited out.
****

3.1 MOORING POINTS IN NEW RIGID PAVEMENTS OR CONCRETE PADS

3.1.1 Location

The mooring device and the attached grounding rod shall be installed within plus or minus 2 inches of the location shown on the Contract Drawings. The top of the mooring device shall be set within 1/4 inch of the plan pavement surface elevation, but not higher than the pavement surface.

3.1.2 Installation

The mooring device shall be installed prior to placement of the concrete pavement. Concrete and reinforcement shall be placed in accordance with specification section (____________________). Hand finishing of the concrete around the mooring devices shall be kept to a minimum.

3.2 MOORING POINTS IN EXISTING RIGID PAVEMENTS

3.2.1 General

The mooring points shall be installed in 12 plus or minus 1/2 inch diameter holes cored through the pavement.

3.2.2 Location

The core holes shall be drilled within plus or minus 1 and 1/2 inches of the location shown in the Contract Drawings. The mooring device and attached grounding rod shall be installed within plus or minus 1/2 inch of the center of the core hole. The top of the mooring device shall be installed within 1/4 inch of the surrounding pavement surfaces, but not higher.

3.2.3 Installation

The holes shall be cored using rotary, non-percussion drilling techniques. The sides of the core hole shall be perpendicular to the pavement surface. Once the pavement is cored the base course shall be excavated as shown in the Contract Plans. The sides of the core hole shall then be cleaned of laitence and roughened by sand blasting. The mooring device shall be screwed on to the grounding rod and tightened sufficiently to allow installation and make electrical contact. The rod and mooring device shall be installed in the core hole by pushing or driving the rod through the pavement base courses and subgrade. The installation technique chosen by the contractor shall not damage the mooring device or grounding rod. The contractor shall then place the concrete around the mooring device in two or more lifts. The first lift should be placed to within 5 inches of the pavement surface and thoroughly consolidated by spud vibrators. The second lift should then be placed and also consolidated by internal vibration. The surface of the concrete shall then be finished and textured to match the adjacent pavement surface and elevation. White pigmented curing compound meeting the requirements of CRD C-300 shall then be uniformly applied at a coverage of not more than 200 square feet per gallon.

3.2.4 Cleanup

The contractor shall control all operations to minimize the amount of dust, dirt, debris and latency in the work area. The contractor shall clean all dirt, dust, debris, or laitence from coring or concreting operations, from the pavement surfaces prior to final acceptance.

3.3 MOORING POINTS INSTALLED IN DRILLED PIERS

3 3.1 General

Excavation of piers shall be performed so that reinforcing steel and concrete placement is a continuous operation performed the same day that the excavation is completed. Excavations shall not be left open overnight. Concrete shall be placed within 3 hours after approval of the completed excavation. Pier drilling equipment shall have the minimum torque capacity and downward force capacity for the contract site conditions.

3.3.2 Government Inspection

The Contracting Officer will inspect each drilled pier excavation. Concrete shall not be placed until the excavation has been approved by the Contracting Officer. The Contractor shall furnish the Contracting Officer all necessary equipment required for proper inspection of drilled pier excavations.

3.3.3 Installation

3.3.3.1 Excavate piers to established depths and dimensions shown. Piers shall be core drilled through pavements. Bottoms of piers shall be cleaned of loose or soft material and leveled. Excavated material shall be disposed of in accordance with Section 02210 GRADING (EARTHWORK).

3.3.3.2 In drilling piers, the surrounding base courses, subgrade, and soil shall be adequately and securely protected against cave-ins, displacement of the surrounding earth, and retention of ground water by means of temporary steel casings. Casings shall have outside diameters not less than the indicated shaft sizes and shall be a minimum of ¼-inch thick. Steel casings shall be withdrawn, as the concrete is being placed, maintaining sufficient head of concrete within the cawing to prevent extraneous material from falling in from the sides and mixing with the concrete. Casings may be jerked upward a maximum of 4 inches to break the bottom seal but thereafter remove with a smooth, continuous motion.

3.3.3.3 The inside of steel casings shall be thoroughly cleaned and oiled before reuse.

3.3.3.4 Water that flows into the excavations shall be continuously removed and all water shall be removed from the excavation bottom, to the extent possible, prior to concrete placement. The maximum permissible depth of water will be 2 inches. In the event of a severe water condition that makes it impossible or impractical to dewater the excavation, concrete shall be placed using underwater tremie after water movement has stabilized.

3.3.3.5 Concrete shall be continuously placed by methods that insure against segregation and dislodging of excavation sidewalls and shall completely fill the shaft. Concrete shall be placed by pumping or drop chutes in dry holes and by tremie or pumping in wet holes. The discharge shall be kept a minimum of 1 foot below the fresh concrete surface during placement. Concrete placement shall not be interrupted in any pier for more than 30 minutes. Concrete shall be vibrated for the full height of the pier.

3.3.3.6 Any pier out of center or plumb beyond the tolerance specified shall be corrected as necessary to comply with the tolerances and the Contractor shall bear any cost of correction. Cross sections of shafts shall not be less than design dimensions. Piers shall be installed with top location deviating a maximum of 2 inches from centerline locations.

3.3.3.7 The Contractor shall replace at no additional cost to the Government, piers found out of tolerance or, found inadequate because of improper construction procedures.

3.3.3.8 The Contractor shall provide protection around top of the excavation to prevent debris from being dislodged into the excavation and concrete.