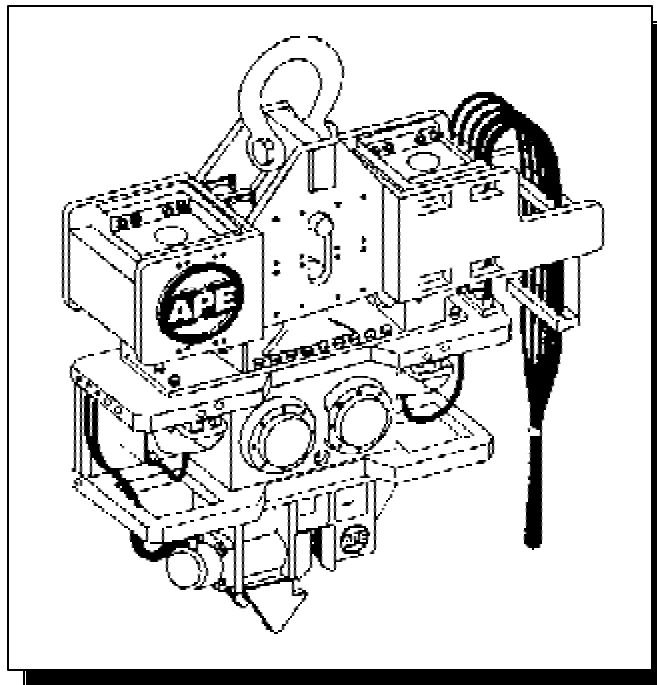




OPERATION AND MAINTENANCE MANUAL



SERIALNUMBER:

**MODEL 150/150T VIBRO
WITH MODEL 350 POWER UNIT**



OPERATION / MAINTENANCE MANUAL

MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

7032 SOUTH 196th - KENT, WA. 98032 - (253) 872-0141 / FAX (253) 872-8710

Preface

General

This manual covers the **Model 150 and Model 150T Vibratory Driver/Extractors and the Model 350 Power Unit**. Most information contained in this manual is identical for all the models covered. The models are therefore grouped together as Model 150/150T and Model 350 where appropriate. The data provided in this manual gives the necessary information to operate and maintain APE equipment. The listed procedures are to be performed by qualified personnel who have an understanding of the equipment and who follow all safety precautions.

Guide to Using the Manual

1. Refer to the Table of Contents for the page location of applicable sections.
2. All weights and measurements in this manual are in both English and Metric units.
3. The manual will be revised as necessary to reflect current information.

Abbreviations

The following are abbreviations used within this manual.

- lbs.** = Pounds
- psi.** = Pounds per Square Inch
- hp.** = Horse Power
- gpm.** = Gallons Per Minute
- rpm.** = Revolutions Per Minute
- eng.** = Engine
- cyl.** = Cylinder
- mm.** = Millimeter
- mtg.** = Mounting
- S/N** = Serial Number
- sol.** = Solenoid

Serial Number Locations

1. **VIBRATOR:** Above and in between the eccentric covers on both sides of the machine.
2. **POWER UNIT:** On back of the hydraulic tank above the APE logo.



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Safety Precautions

(This list of precautions must be followed at all times to ensure personal & equipment safety.)

1. Read this manual from beginning to end before operating or working on this machine.
2. When operating in a closed area, pipe exhaust fumes outside. **(WARNING:** Breathing exhaust fumes can cause serious injury and even death.)
3. When servicing batteries, avoid any type of spark or open flame. Batteries generate explosive gases during charging. There must be proper ventilation when charging batteries.
4. Never Adjust or repair the unit while it is in operation.
5. Make sure the Control Pendant is in the "OFF" position before starting the unit.
6. Remove all tools and electrical cords before starting the unit.
7. Keep oily rags away from the exhaust system.
8. Never store flammable liquids near the engine.
9. Never stand under vibro at any time and keep your eyes on the vibro when it is in operation. Keep a look out for loose bolts or leaking hydraulic lines.
10. Avoid pulling on hose quick dis-connect fittings. Move power unit closer to work if hoses cannot reach. Do not use hoses as a tow line to tug the power unit! If a hose fails at the hydraulic couplers then it is a result of "hose tugging by the pile crew".
11. Avoid kinks in the hoses. Kinks will cut the hose safety factor by 50 percent.
12. Always wear eye and ear protection.
13. Avoid standing downwind of vibrating piles. Dirt and other matter may become airborne and fall into the unprotected eye.
14. Always wear a hardhat, gloves, and safety shoes.
15. Always attach safety line to pile when extracting or hoisting into position.
16. **(WARNING)** Never clamp vibro to pile and dis-connect from crane line. Lay vibro down on ground when not in use.
17. Do not truck power unit with quick disconnect caps and plugs screwed on to fittings unless the caps and plugs have wire rope safety lines attached. Store in storage box under control panel.



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Warranty American Piledriving Equipment, Inc. STANDARD WARRANTY

American Piledriving Equipment, Inc. (APE/J&M) warrants new products sold by it to be free from defects in material or workmanship for a period of one year after the date of delivery to the first user and subject to the following conditions: APE/J&M's obligation and liability under this WARRANTY is expressly limited to repairing or replacing at APE/J&M's option, any parts which appear to APE/J&M upon inspection to have been defective in material or workmanship. Such parts shall be provided at no cost to the user, at the business establishment of APE/J&M or the authorized APE/J&M distributor of the product during regular working hours. This WARRANTY, shall not apply to component parts or accessories of products not manufactured by APE/J&M and which carry the warranty of the manufacturer thereof, or to normal maintenance (scraped and skived lube and fuel lines, worn cushion material in the drive base) or normal maintenance parts (such as fouled injectors, weakened check valve springs, damaged grease fittings caused by use over time). Replacement or repair parts installed in the product covered by this WARRANTY are warranted only for the remainder of the warranty as if such parts were original components of said product. APE/J&M makes no other warranty, expressed or implied and makes no warranty of merchantability of fitness for any particular purpose.

APE's obligation under this WARRANTY shall not include any transportation charges, costs of installation, duty, taxes or any other charges whatsoever, or any liability for direct, indirect, incidental or consequential damage or delay. If requested by APE/J&M, products or parts for which a warranty claim is made are to be returned transportation prepaid to APE/J&M. Any improper use, including operation after discovery of defective or worn parts, operation beyond rated capacity, substitution of any parts whatsoever, or parts not approved by APE/J&M or any alteration or repair by others in such manner as in APE/J&M's judgment affects the product materially and adversely, shall void this warranty.

ANY TYPE OF WELDING ON EQUIPMENT WILL VOID THE WARRANTY

Refusal: Vibros: If the pile does not move one foot in 30 seconds of vibro operation (driving or pulling) at full speed. Resort to a larger vibro. APE/J&M equipment may exceed the refusal driving criteria for short periods of time as may be needed to penetrate hard soil layers or obstacles. In such cases, a heat gun is used to monitor the temperature of the bearings and related components to prevent use of the machine beyond 195 degrees F. Contact APE/J&M or your local APE/J&M distributor for special instructions when faced with refusal conditions.

Refusal: Diesels: Do not exceed 10 blows per inch or 120 blows per foot. In cases of setting of the pile it is permitted to increase the blow count to 250 blows per foot, but only for one foot of driving penetration. Pile inspectors should consult the APE factory for permission to exceed these limits. Failure to do so will void the warranty. This standard specification is accepted by the DFI (Deep Foundations Institute) and the PDCA (Pile Driving Contractors Association) and by all manufacturers of pile driving equipment.



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I-1. Machine Features. - Model 150/150T Vibratory Hammer

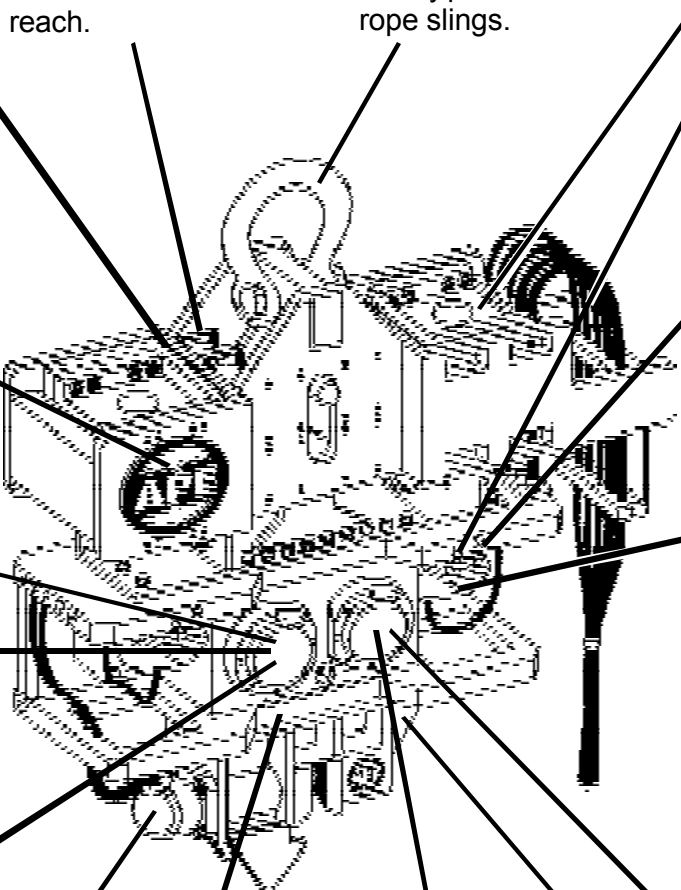
Patented breakthrough suppressor cuts down weight while increasing line pull.

Three feet shorter than any vibro in its class. Gain more headroom and reach.

80 Ton Crosby shackle and safety pin eliminate liability problems with wire rope slings.

80 Ton pull! Twice the pulling ability of other vibros.

Suppressor is modular and can be removed to reduce suspended weight to 5,000lbs (2,272kg.). Height can be reduced to 43" (1,092mm).



Gear box incorporates a machined O-ring groove to seal the top plate with no leaky gaskets.

Rifle bored top plate eliminates unwanted hoses that can cause serious downtime. (15-less hoses.)

One piece eccentric/ gear design eliminates bolts, keyways, splines and pins.

Hydraulic motors are recessed which eliminates the need for bolted on guards. Less parts - less problems. Vertical motor mounting is approved by Volvo.

Two eccentrics filled with "heavy metals" produce more amplitude with less parts.

Computer designed gear-box is perfectly balanced with very low center of gravity. Release crane line without the worry of bending piles.

Giant spherical bearings are five times larger than those found on other machines.

Heavy cylinder needs no guards and all hoses are tucked out of harms way. The one piece design eliminates rear seals, tie rods & nuts.

Gear box drilled to accept attachments manufactured by APE and by other manufacturers.

High speed gear train will allow vibro to operate off many different power units.

The 150/150T vibro can be shipped fully assembled on a Boeing 747 aircraft.

Figure 1-A. Machine Features



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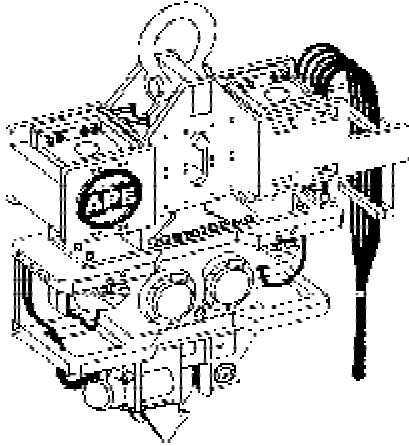
MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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I. GENERAL INFORMATION (Continued...)

I-2. Machine Specifications

I-2A. Model 150/150T Vibro - (Table 1-A.)



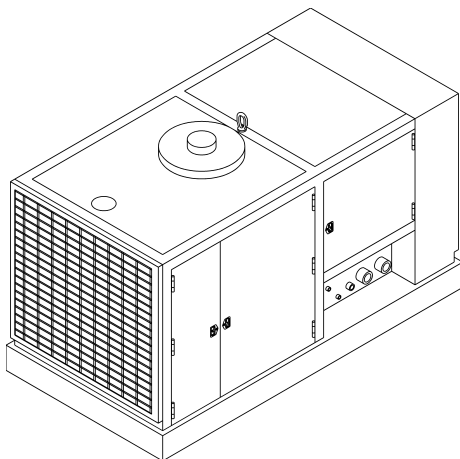
	Model 150	Model 150T
Eccentric Moment	2,000 in-lbs (25.35 kg-m)	2,600 in-lbs (29.96 kg-m)
Drive Force	50 to 85 Tons (756 kN)	50 to 100 Tons (894 kN)
Frequency (vpm)	0 to 1,650	0 to 1,650
Amplitude	1/4" to 0.75" (28.5 mm)	1/4" to 0.75" (28.5 mm)
Pile Clamp Force	226 Tons (2,010 kN)	226 Tons (2,010 kN)
Line Pull for Extraction	108 Tons (961 kN)	108 Tons (961 kN)
Hydraulic Hose Length	150' (30 m)	150' (30 m)
Suspended Weight*	8,200 lbs. (3,718 kg)	8,500 lbs. (3,855 kg)
Length	88.75" (2,254 mm)	88.75" (2,254 mm)
Width at Throat Height	14.25" (362 mm)	14.25" (362 mm)
Height w/o Clamp	72.38" (1,838 mm)	72.38" (1,838 mm)
Height with Clamp**	100.13" (2,438 mm)	100.13" (2,438 mm)

* Suspended weight can be reduced to 5300 lbs.

**Weight and height includes sheeting clamp and 1/2 of hose bundle.

***Drive force increases with increase in frequency. However, an increase in drive force may reduce productivity in some soils. APE provides variable frequency on all vibros so that frequency can be adjusted to suit many different soil conditions. For more details on what frequency works best for the soil conditions on your site please call APE directly.

I-2B. Model 350 Power Unit - (Table 1-B.)



	Model 350
Engine	350 hp Cat C9
Maximum Power	350 hp (261 kW)
Operating Speed	800 to 2100 rpm
Maximum Drive Pressure	4,800 psi (331 bar)
Max.Hyd.Flow-Forward	120 gpm (454 lpm)
Max.Hyd.Flow-Reverse	65 gpm (254 lpm)
Clamp Pressure	4,800 psi (344 bar)
Clamp Pump Flow @ 2100 rpm	10 gpm (38 lpm)
Weight	12,600 lbs (5,715 kg)
Length	137" (3,480 mm)
Width	77" (1,956 mm)
Height	84" (2,134 mm)

**Dimensions may vary depending on the year and model.
Consult the factory for certifications on unit being used.**



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I. GENERAL INFORMATION (Continued...)

I-3. General Description of Model 150/150T Vibro

The **APE Model 150/150T** is a variable frequency vibratory pile driver/extractor designed to drive and extract all types of piles including sheet, pipe, timber, concrete, H-beam, I-beam and steel plates. In addition, the vibrator can be used for soil compaction, installing well casings, and installation of tie-backs and wick drains.

The Model 150/150T operates in a frequency range of 0 to 1650 cycles per minute depending on the hydraulic flow and on the hydraulic motors fitted to the gear train. The Model 150/150T is especially suited for driving or extracting piles that are near buildings or other structures. This is because the Model 150/150T vibrates at higher frequencies and thus is less damaging to surrounding soils.

The three major parts to the Model 150/150T are as follows:

- A.)** The Suppressor housing.
- B.)** The Gearbox.
- C.)** The Clamping Attachment.

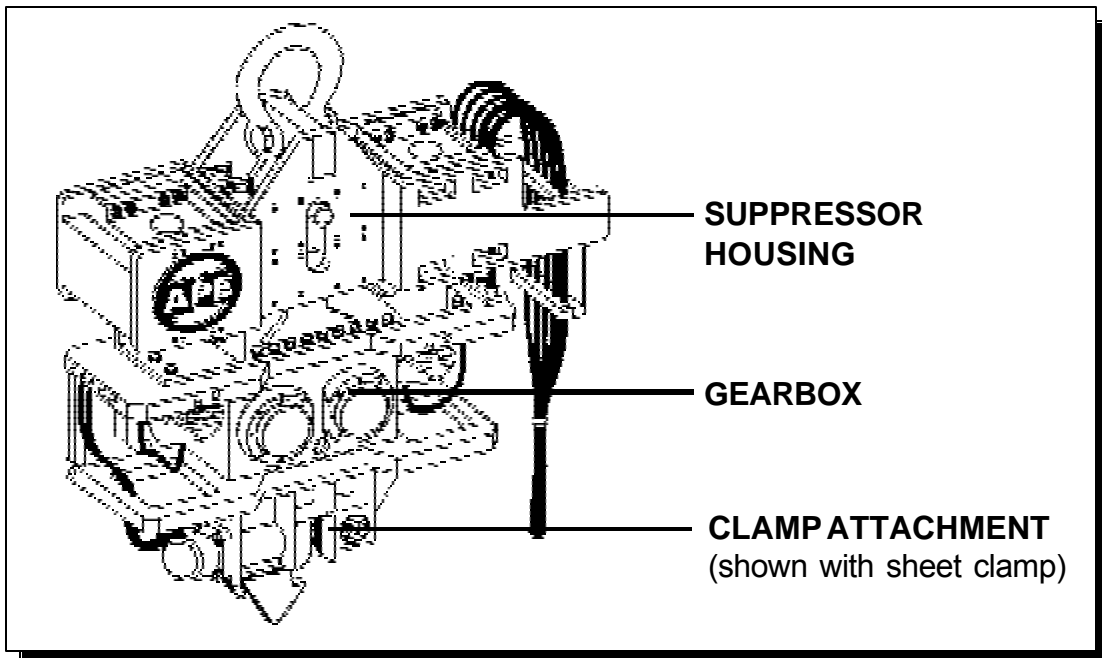


Figure 1-B. General Description of 150/150T Vibro.



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I. GENERAL INFORMATION (Continued...)

I-3A. Suppressor Housing

The suppressor housing of the **150/150T APE Vibrator** is a patented multi-stage system consisting of two large rubber elastomers and eight small elastomers. The large rubber elastomers (technically called the first stage) are used during all driving operations and light to medium extraction. The second stage is made up of eight small high capacity elastomers that do not engage until the crane has pulled approximately 10 tons of line pull. A large safety pin fitted inside a view slot indicates total line pull in tons. The safety pin travels down in the view slot during the extraction process. One inch of travel is equal to eight tons of line pull. (**WARNING! Hard pulling for long periods of time will heat and damage the large elastomers. The heat generated from constant heavy line pull will destroy the chemical bond between the rubber and mounting plate which will cause elastomer failure.**) When engaged in hard extracting, break every 15 minutes to allow elastomers to cool.

Note: for batter operations it has been discovered that slightly reducing the oil level in the vibro gearcase will reduce heat. In these cases, fill the gearbox until the oil level is half way up the sight glass and then drain until the level is near the bottom.

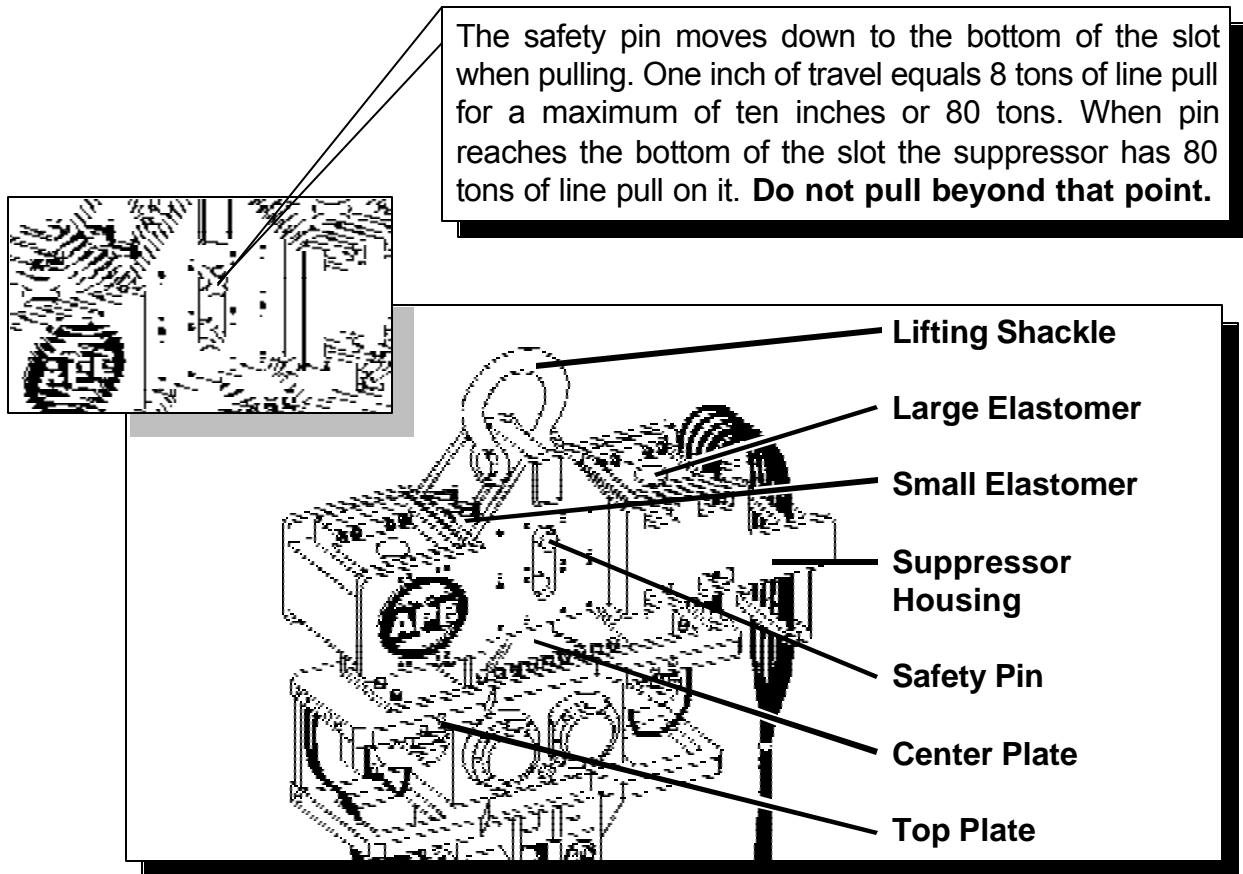


Figure 1-C. General Description of Suppressor Housing.



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I. GENERAL INFORMATION (Continued...)

I-3B. Vibrator Gearbox

The vibrator gearbox contains two high amplitude eccentric weights cast in one piece with the gear. This design is unique to the industry and was developed by the engineers of APE to solve a number of problems associated with other types of vibrator machines. Both the eccentric and the drive gears have been helically cut to provide high speed operation with reduced noise and wear. Vibration is caused by the vertical movement created when the eccentrics are rotated. The eccentric and drive gears are all driven in line by two Volvo or Rexroth 125 motors tucked in on the outboard side of the gearbox. The motors are recessed for maximum protection. The eccentrics rotate on two shafts housed by four giant spherical bearings. The gears and bearings receive lubrication as a result of the fluid splashing inside the gearbox when the gears are rotated. The oil level is quickly determined by looking at the site gauge. The Model 150/150T can be operated under water to a depth of 30 feet without modifications. (Consult factory for depths below 30 feet.)

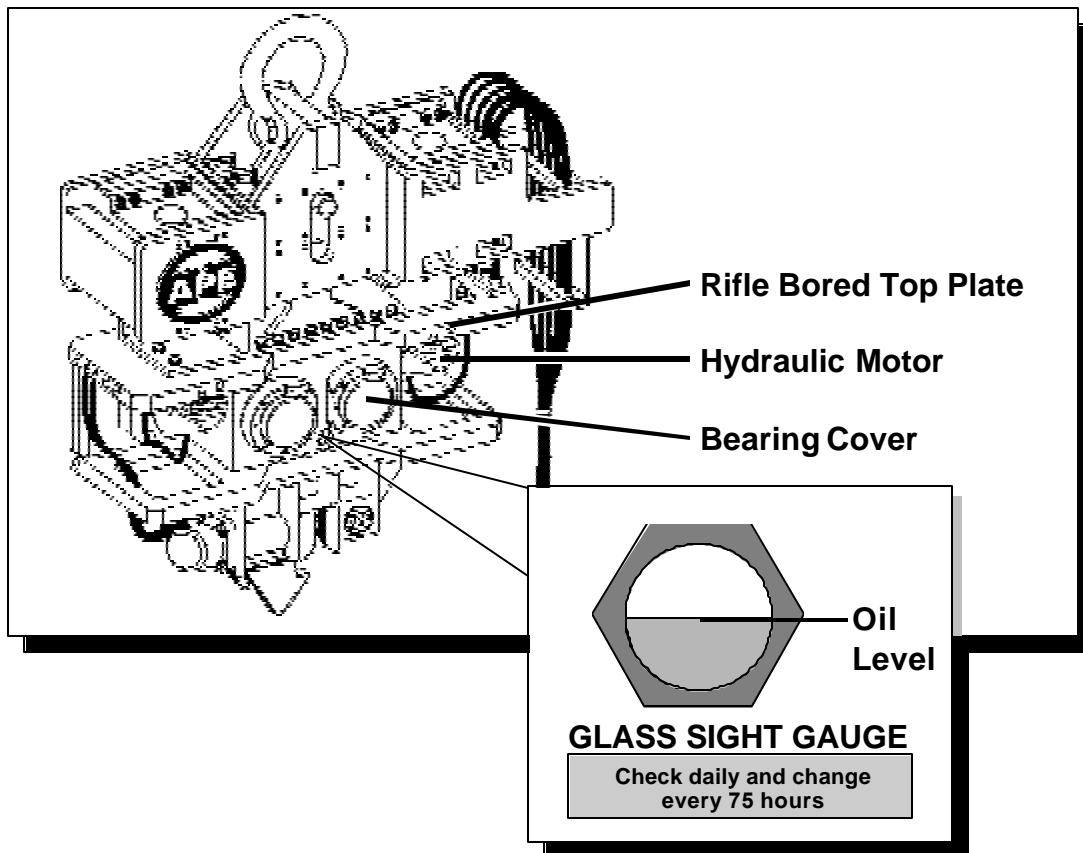


Figure 1-D. General Description of Vibrator Gearbox.



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I. GENERAL INFORMATION (Continued...)

I-3C. Clamp Attachment

The APE 150/150T come with a **standard sheet pile clamp attachment**. The clamp contains two gripping jaws. One is "fixed" and one is "moveable". A large hydraulic cylinder operates the moveable jaw with up to 250 tons of clamping force depending on clamp pump relief pressure. The jaws open and close by turning a switch on the remote control pendant or may be operated by turning the switch at the main control panel mounted behind one of the doors on the power unit. The valve can be manually operated with a screwdriver if all electrical fails. **The APE standard sheet pile clamp** can be fitted with jaws to fit many different types of piles including sheet piles, H-Beams, steel plates, steel rods, pipe piles, wood piles, and concrete piles. (Contact APE or your local APE distributor for more information on clamp attachments for special pile types.)

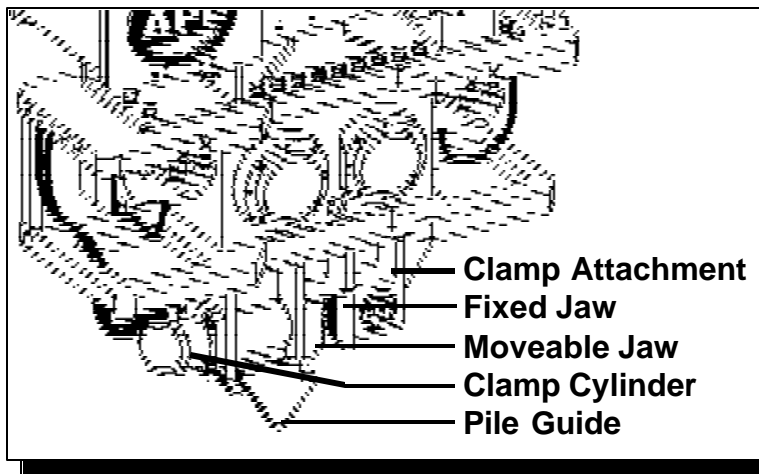
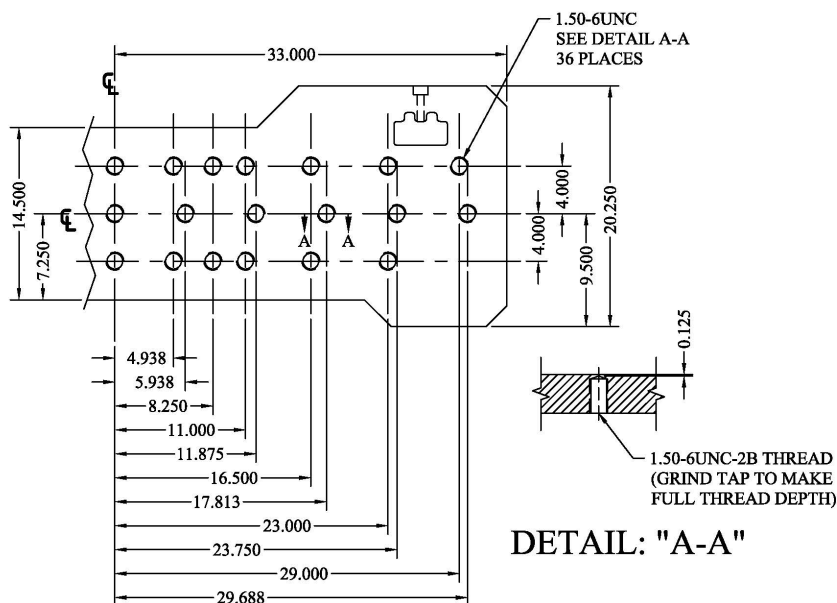


Figure 1-E. General Description of Clamp Attachment.



Notice: If you are involved in changing a clamp attachment then please train your crew to clean the machined surfaces of both the bottom of the vibro and the top of the clamp so that when they bolt the two together they will mate up properly. Sometimes a crew will forget to do this and the dirt or dent in the metal plates will prevent the bolts from coming fully tight. When this happens, the clamp bolts break. If a bolt breaks, it is a direct result of a sloppy mechanic that failed to use common sense when installing a clamp attachment.

Figure 1-F. Clamp Attachment Hole Configuration.



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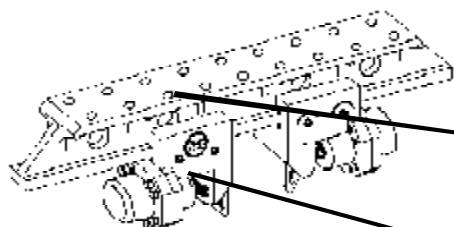
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I. GENERAL INFORMATION (Continued...)

I-3D. Optional Attachments

The following are some of the optional attachments for the Model 150/150T Vibratory hammer. (Contact APE or your local APE distributor for more information about these and other available equipment.)



7 ft. Caisson Beam (#901000)

8 ft. Caisson Beam (#902000)

11ft. Caisson Beam (#903000)

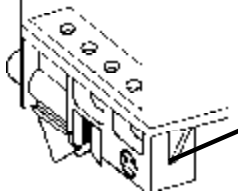
Caisson Clamp (#250000)

APE CAISSON CLAMP



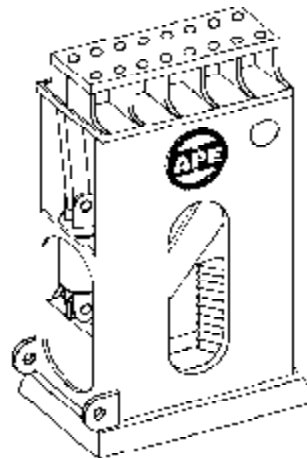
90 Degree Adapter Plate (#905000)

4 ft. Extension Adapter (#906000)



Clamp Attachment

APE 90 DEGREE ADAPTER WITH EXTENSION



APE DELUXE WOOD CLAMP (#907000)

Figure 1-G. Optional Attachments



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I. GENERAL INFORMATION (Continued...)

I-4. General Description of Model 350 Power Unit

The 150/150T vibrator runs off the APE 350 power unit. The engine is mounted to a tubular frame that also serves as a diesel fuel tank. A sheet metal and tube frame covers the engine and is equipped with locking doors for protection from the environment. A control panel is located behind one of the doors and comes complete with a 50 foot control pendant. There are two hydraulic tanks on the power unit. One is the main tank and the other is a storage tank for extra oil in case the main tank becomes depleted. A hydraulic tank supplies oil to five pumps. Three pumps feed the two vibrator motors. A pump circulates oil through the oil cooler and filters back into the hydraulic tank. The other pump feeds the clamp attachment. The Vibrator is connected to the power unit via five hydraulic hoses. The two large 1 1/2" hoses are the pressure and return lines for the vibrator motors. The two 3/8" hoses are for the clamp system and the one 3/4" hose is for the vibrator motor case drain line. The hoses are attached to the power unit by connecting the "quick disconnect fittings" on the end of the hoses leading from the vibrator. The fittings go on only one way so there is no chance of hooking up the hoses improperly.

WARNING: Clean with ether or a clean rag before installing quick disconnects. Make sure you seat the quick disconnect fittings all the way tight. Failure to tighten the quick disconnects will stop the flow of oil and will prevent the vibro from operating. Failure to tighten the clamp fittings completely tight will cause the jaws to either not open or not close. If this happens you may have to crack the fitting and bleed off the pressure to release the quick disconnects.

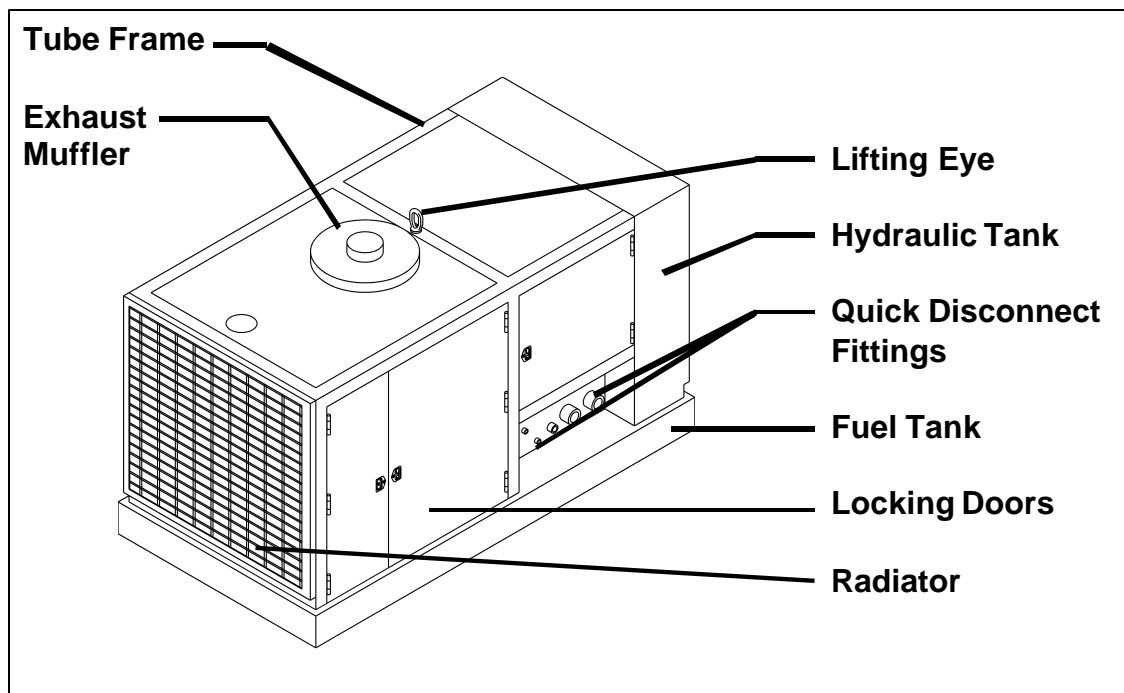


Figure 1-H. General Description of Model 350 Power Unit



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II. COMPONENT DEFINITION

II-1. Vibro Identification

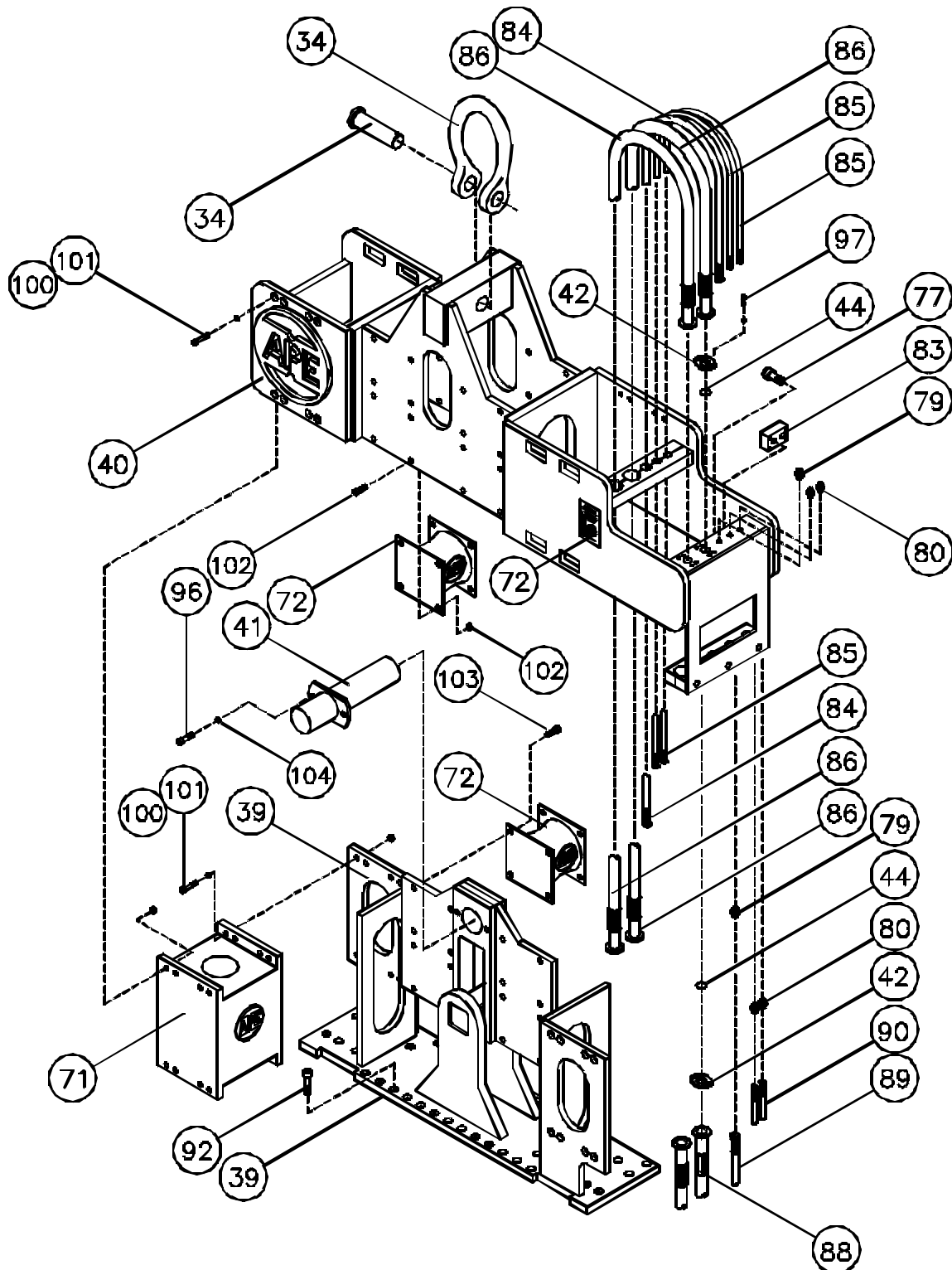


Figure 2-A1 Model 150/150T Suppressor Component Location



OPERATION / MAINTENANCE MANUAL

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II. COMPONENT DEFINITION

II-1. Vibro Identification

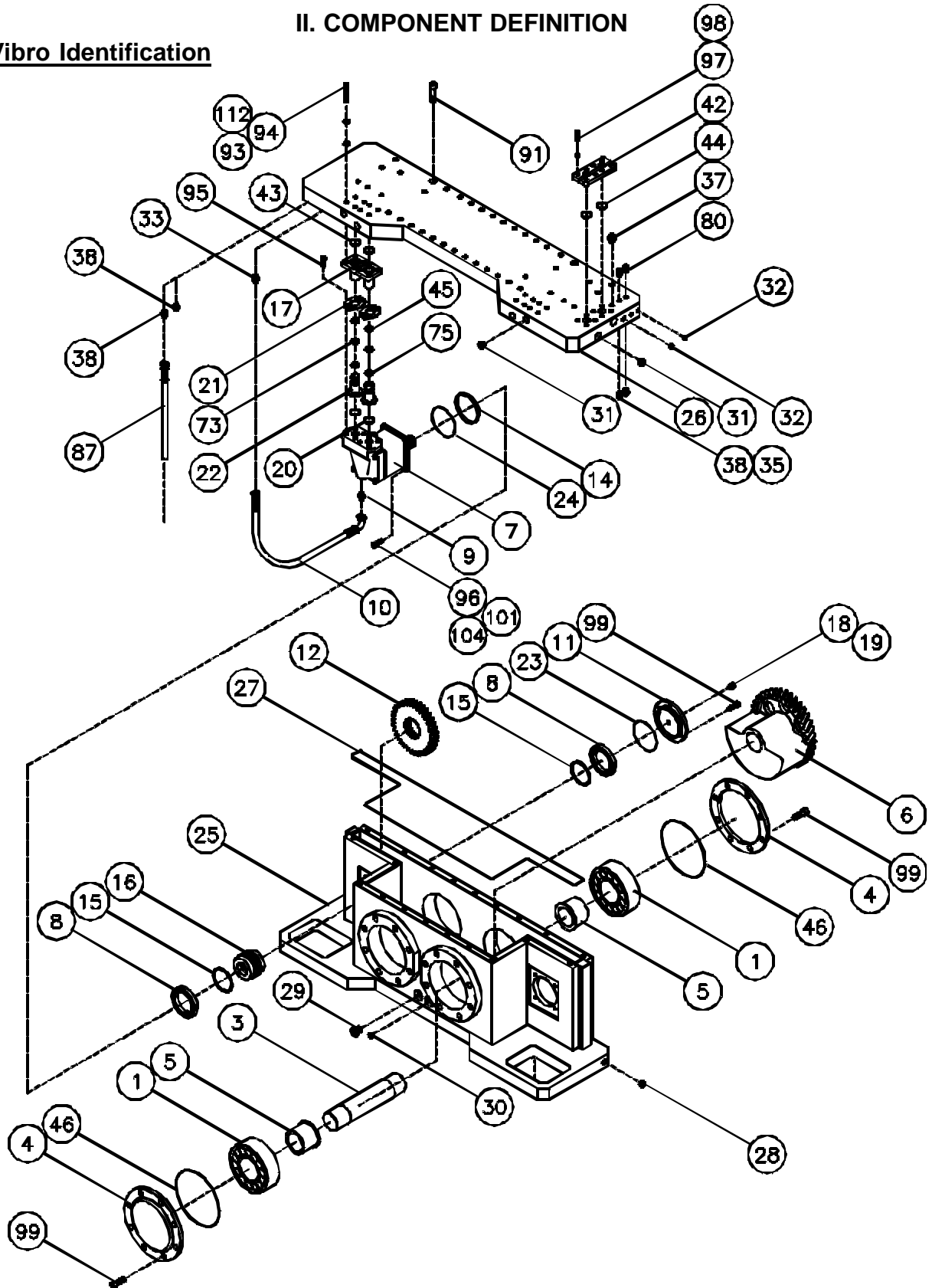


Figure 2-A2 Model 150/150T Gearbox Component Location



OPERATION / MAINTENANCE MANUAL

MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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II. COMPONENT DEFINITION (Continued...)

II-2. Hose Identification.

The following is a general listing of the standard hoses that are shipped with the Vibro

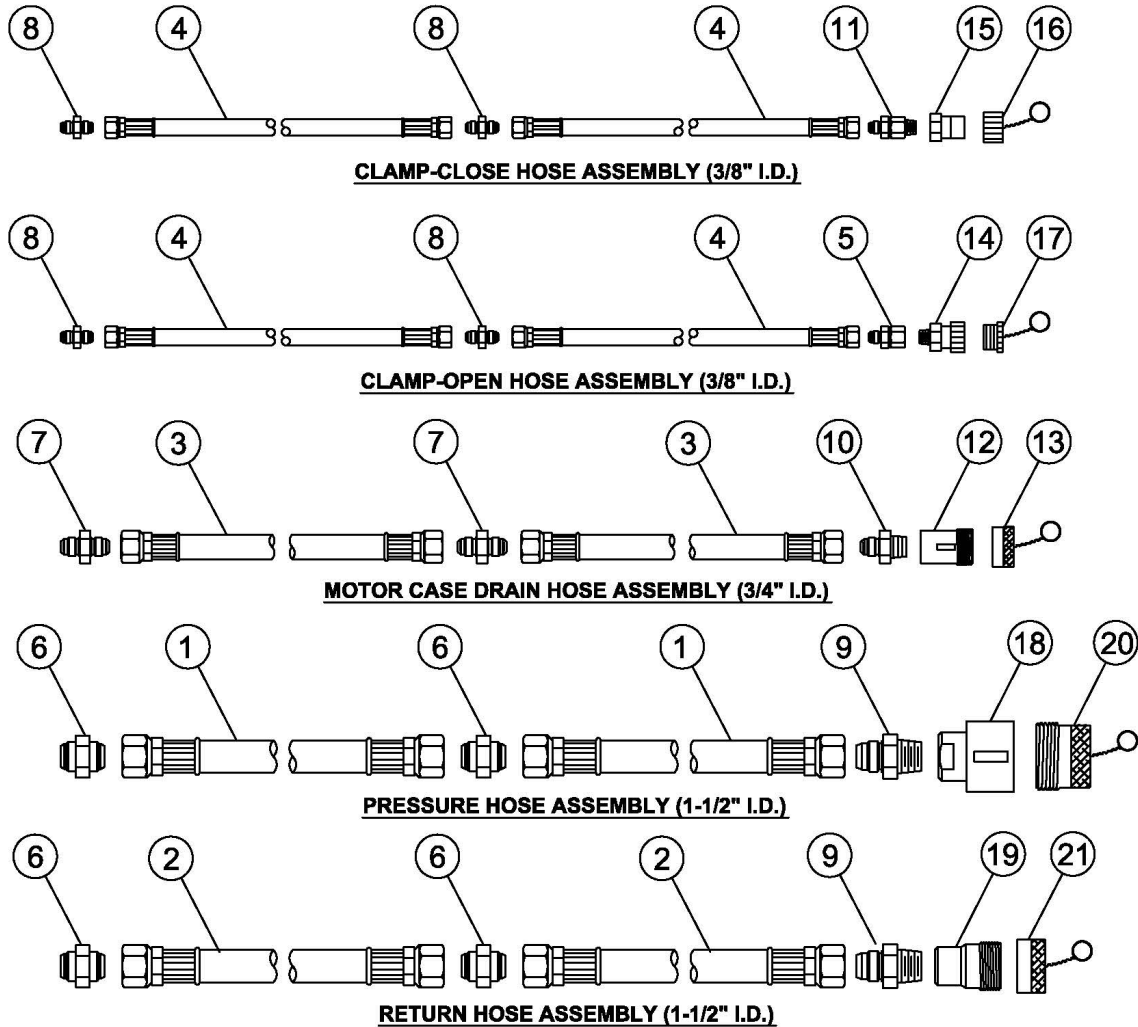


Figure 2-B Hose Bundle Identification

Item	Qty	Description	Part #
1	2	1 1/2" Hose x 50'	#421008
2	2	1 1/2" Hose x 50'	#421008
3	2	3/4" Two Wire Hose x 50'	#421009
4	4	3/8" Gates Hose x 50'	#421010
5	1	Fitting #6 JIC Male/#6 Female	#421011
6	4	Fitting #24 Male JIC Union	#421012
7	2	Fitting #12 Male JIC Union	#421013
8	4	Fitting #6 Male JIC Union	#421014
9	2	Fitting #24 JIC/#24 Pipe	#421015
10	1	Fitting#12 JIC/#12 Pipe	#421016

Item	Qty	Description	Part #
11	1	Fitting #6 JIC/#6 Pipe	#421017
12	1	3/4" Male Q.D.	#421020
13	1	3/4" Dust Cap	#421021
14	1	3/8" Female Q.D. #S35-3	#421024
15	1	3/8" Male Q.D. #S31-3	#421025
16	1	3/8" Cap #S39-3	#421026
17	1	3/8" Plug #S34-3	#421027
18	1	1-1/2" Female Q.D.	#400301
19	1	1-1/2" Male Q.D.	#400300
20	1	1-1/2" Dust Plug	#400704A
21	1	1-1/2" Dust Cap	#400703A

Table 2-B Hose Identification.

II. COMPONENT DEFINITION (Continued...)

II-3. 150 Sheet Clamp Identification

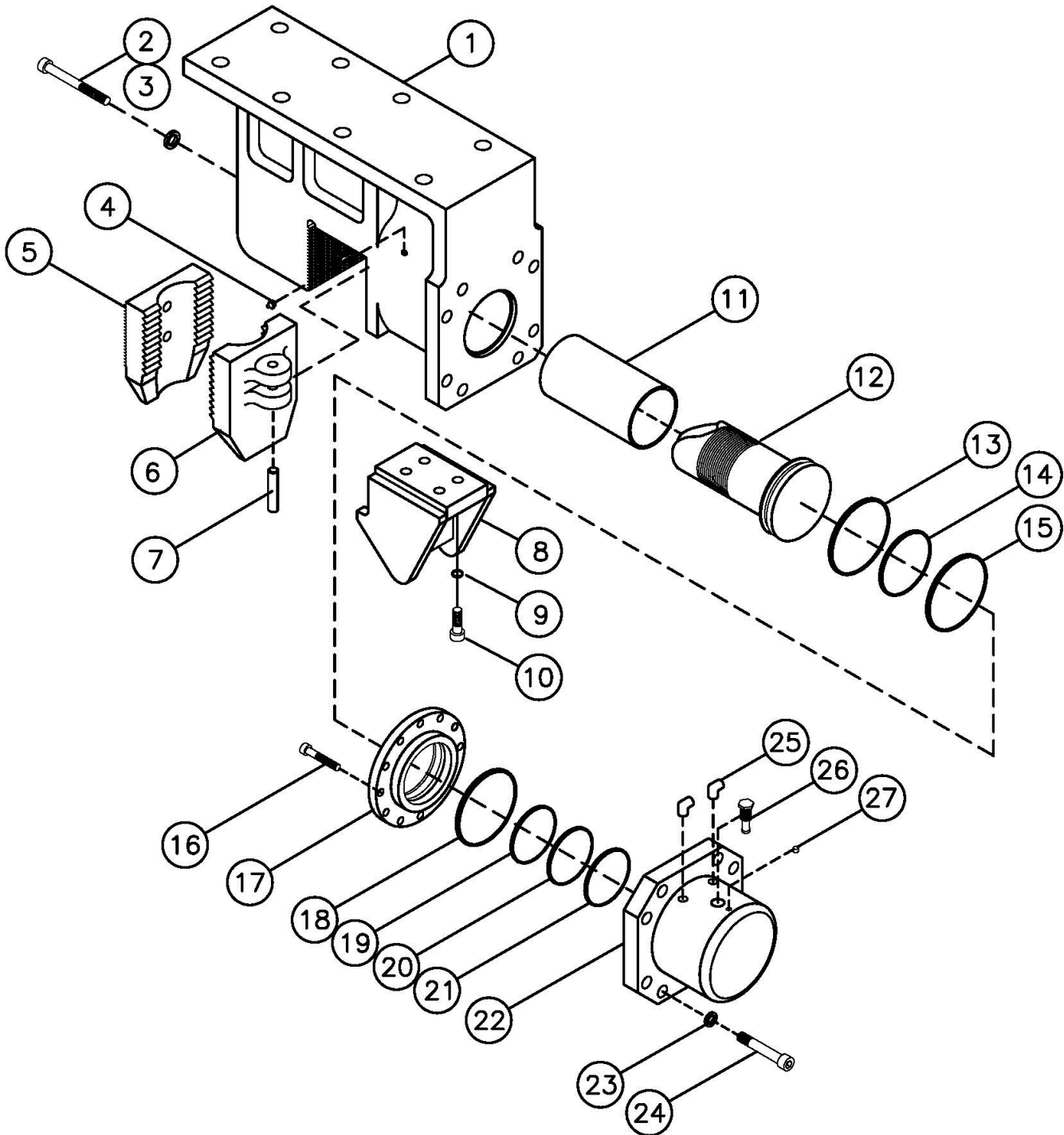


Figure 2-C 150 Sheet Clamp Identification



OPERATION / MAINTENANCE MANUAL

MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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II. COMPONENT DEFINITION (Continued...)

II-3. 150 Sheet Clamp Identification

<u>ITEM</u>	<u>QTY</u>	<u>DESCRIPTION</u>	<u>PART #</u>
1	1	Clamp Body	221019
2	2	Bolt-SHCS 1" NC X 9"	124206
3	2	1" High Collar Lock Washer	124207
4	1	1/8" Grease Zerk	221001
5	1	Fixed Jaw	221011
6	1	Moveable Jaw	221005
7	1	Jaw Pin	221002
8	1	Sheet Pile Guide Assy.	221017
9	4	1" High Collar Lock Washer	124207
10	4	Bolt-SHCS 1" NC X 3"	124208
11	1	Plastic Sleeve	222020
12	1	Piston / Rod	222007A
13	1	Parker O-Ring R-5100-128	222010
14	1	Parker Expander #442	222010
15	1	Parker Molygard W2-8000-750	222010
16	12	Bolt-SHCS 5/8 NF (Machined)	124209
17	1	Cylinder Gland	222302
18	1	Parker O-Ring 2-367 w/ 8-367	222010
19	1	Parker Wiper SH959-53	222010
20	1	Parker Polypak 2500-6000-375B	222010
21	1	Parker Molygard W2-6250-750	222010
22	1	Clamp Cylinder	222001
23	8	1-1/4" High Collar Lock Washer	124205
24	8	Bolt-SHCS 1-1/4" NF x 3-1/2"	124204
25	2	#6 SAE - #6 JIC 45° Fitting	222002
26	1	Check Valve	222016
27	1	#6 SAE Allen Plug	222017

Note: All seals & o-rings are part of kit 222010

Table 2-C 150 Sheet Clamp Identification



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MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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II. COMPONENT DEFINITION (Continued...)

II-4. Model 350 Power Unit Skid Identification.

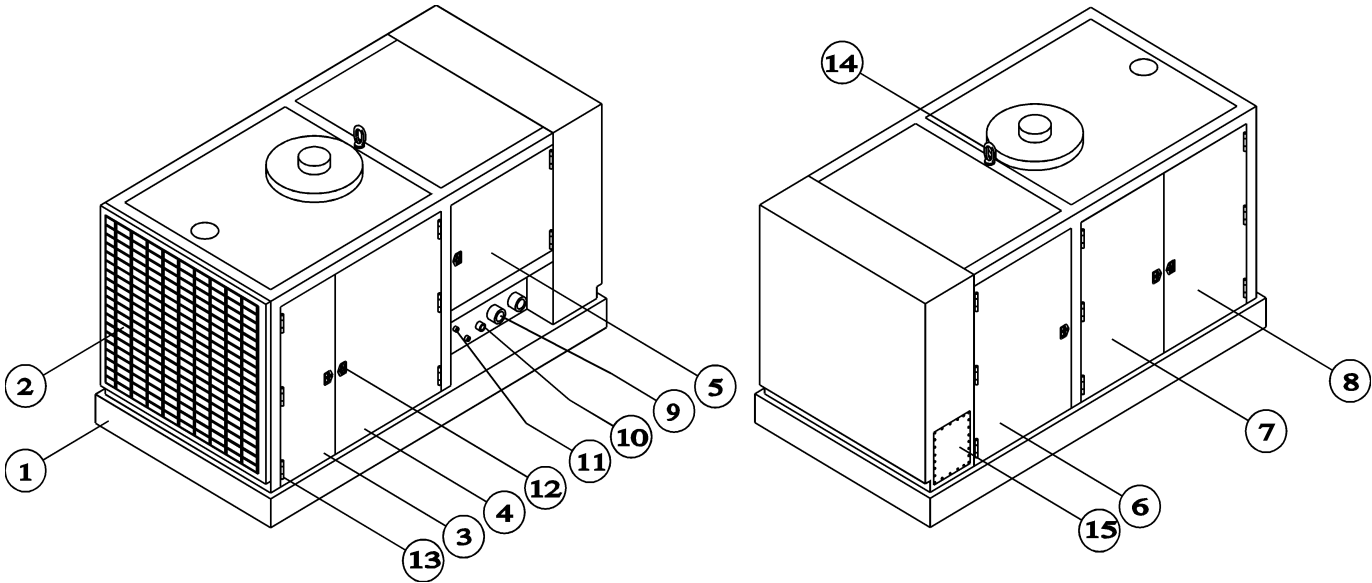


Figure 2-D Model 350 Power Unit Skid Identification.

Item	Qty	Description
1	1	Model 330 Power Unit Skid
2	1	Radiator Grill
3	1	Door 22-5/8" x 51"
4	1	Door 40-3/8" x 51"
5	1	Door 33-1/2" x 19-1/2"
6	1	Door 33-1/2" x 51"
7	1	Door 40-3/8" x 51"
8	1	Door 22-5/8" x 51"
9	2	1-1/2" Hydraulic Q.D. (1) Female (1) Male
10	1	3/4" Hydraulic Q.D. Female
11	2	3/8" Hydraulic Q.D. (1) Female (1) Male
12	6	Door Handle / Lock
		Lock-#EMC 56462W Two Point Lock
		Handle-#EMC 48742W Locking Handle
13	17	Hinges Weld On
14	1	Lifting Eye
15	2	Clean Out Cover 15" x 18"
16	1	Clean Out Cover 12" x 15"

Table 2-D Model 350 Power Unit Skid Identification



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MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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II. MAJOR COMPONENT DEFINITION (Continued...)

II-5. Quick Disconnect Couplings.

The APE Quick Disconnect Couplings are high pressure hydraulic couplings designed for rugged applications. Service in many such applications has proven the design compatible to extreme pressures, structural and system induced shock loads. The construction of the coupling assembly promotes ease of use and maintenance.

Design Features:

- Excellent flow characteristics for continuous duty applications.
- High strength design endures high surge and shock conditions.
- Flat crested stub-ACME threads and all steel construction withstand storage and rig-up damage.
- Structurally compatible with weight of 5,000 P.S.I. flex-hose and system induced shock loads.

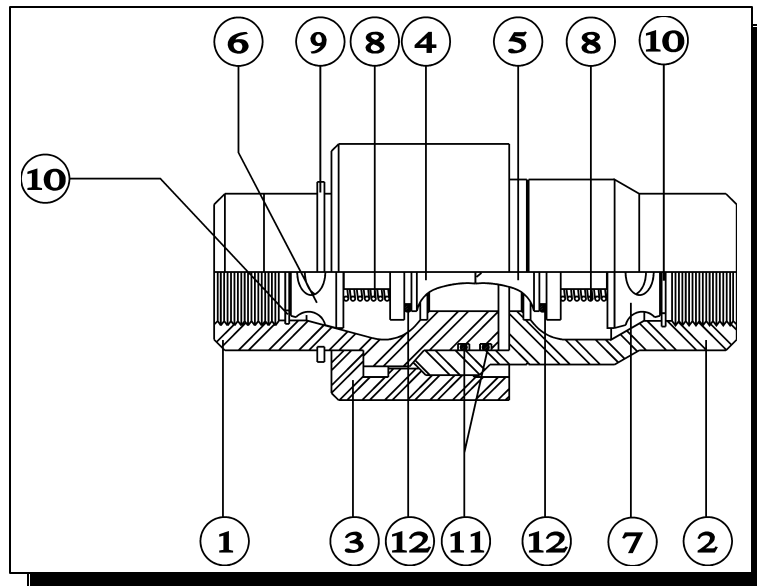


Figure 2-E 1-1/2" Quick Disconnect Coupling

Item	Qty	Description	
1	1	Q.D. Hydraulic Female Coupling	400301
2	1	Q.D. Hydraulic Male Coupling	400300
3	1	Q.D. Hydraulic Coupling Sleeve	400302
4	1	Q.D. O-Ring Carrier "A"	400202
5	1	Q.D. O-Ring Carrier "B"	400201
6	1	Q.D. Plunger	400101
7	1	Q.D. Plunger	400101
8	1	Q.D. Plunger Spring	400701
9	1	Retaining Ring - "Inverted External" #I-275	
10	2	Retaining Ring - "Truarc Internal" #N5000-168	
11	2	Parker O-Ring #2-230 & One Parback	
12	2	Parker O-Ring #2-216	

Table 2-E 1-1/2" Quick Disconnect Coupling



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II. MAJOR COMPONENT DEFINITION (Continued...)

II-6. 100 Caisson Clamp Identification

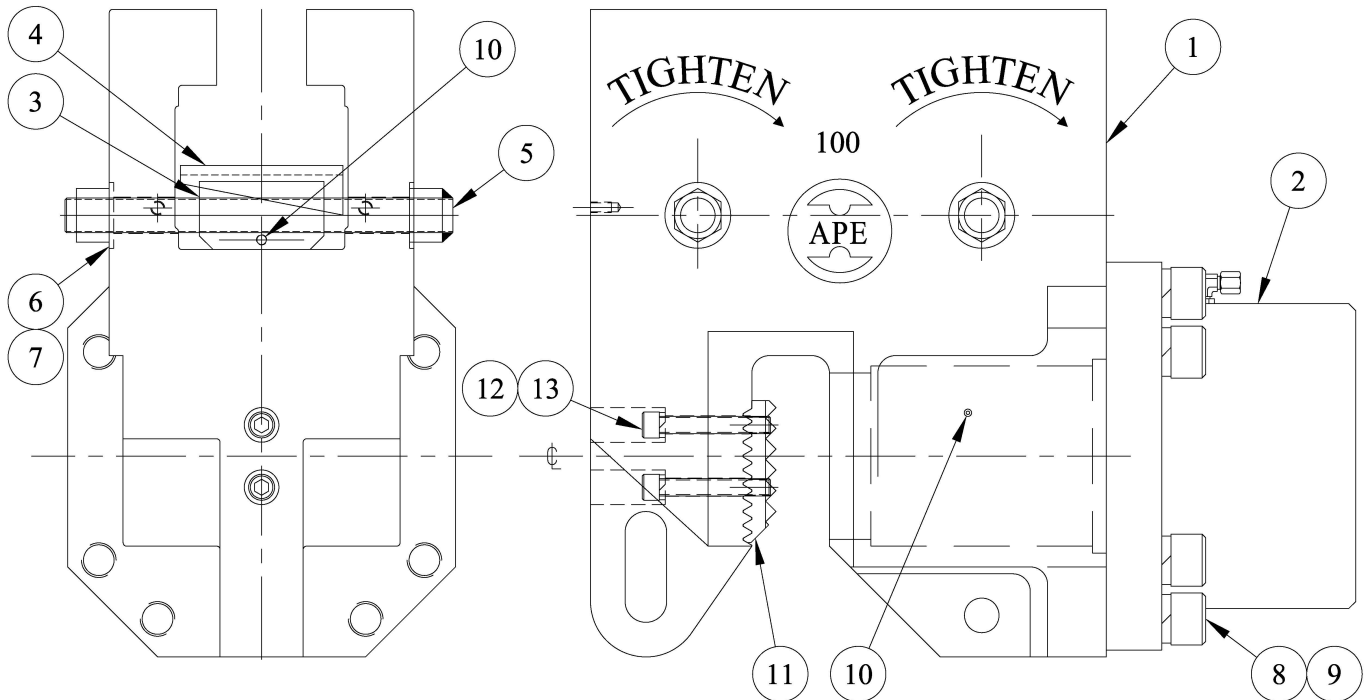


Figure 2-F 100 Caisson Clamp Identification

Item	Qty	Description	Part #
1	1	Caisson Clamp Body	#250101
2	1	Caisson Clamp Cylinder Asm	#250001
3	2	Wedge-Male-Half Bronze	#250102
4	2	Steel Wedge	#250105
5	2	Caisson Wedge Screw Asm	#124211A
6	2	Washer Caisson Flat 1-1/8"	#124219
7	2	Nut ACME Heavy Hex 1-1/4"	#243102
8	8	SHCS 1-1/4-12 X 4.00 Lg	#124204
9	8	Hi Collar L/W 1-1/4"	
10	5	Grease Fitting	#221001
11	1	Jaw-Caisson-Std Thick	#250202
12	2	SHCS 5/8-11 UNC X 4.00 Lg.	#110308
13	2	Hi Collar L/W 5/8"	#124115

Table 2-F 100 Caisson Clamp Identification



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II. MAJOR COMPONENT DEFINITION (Continued...)

II-7. Caisson Clamp Cylinder Asm Identification p/n 250001

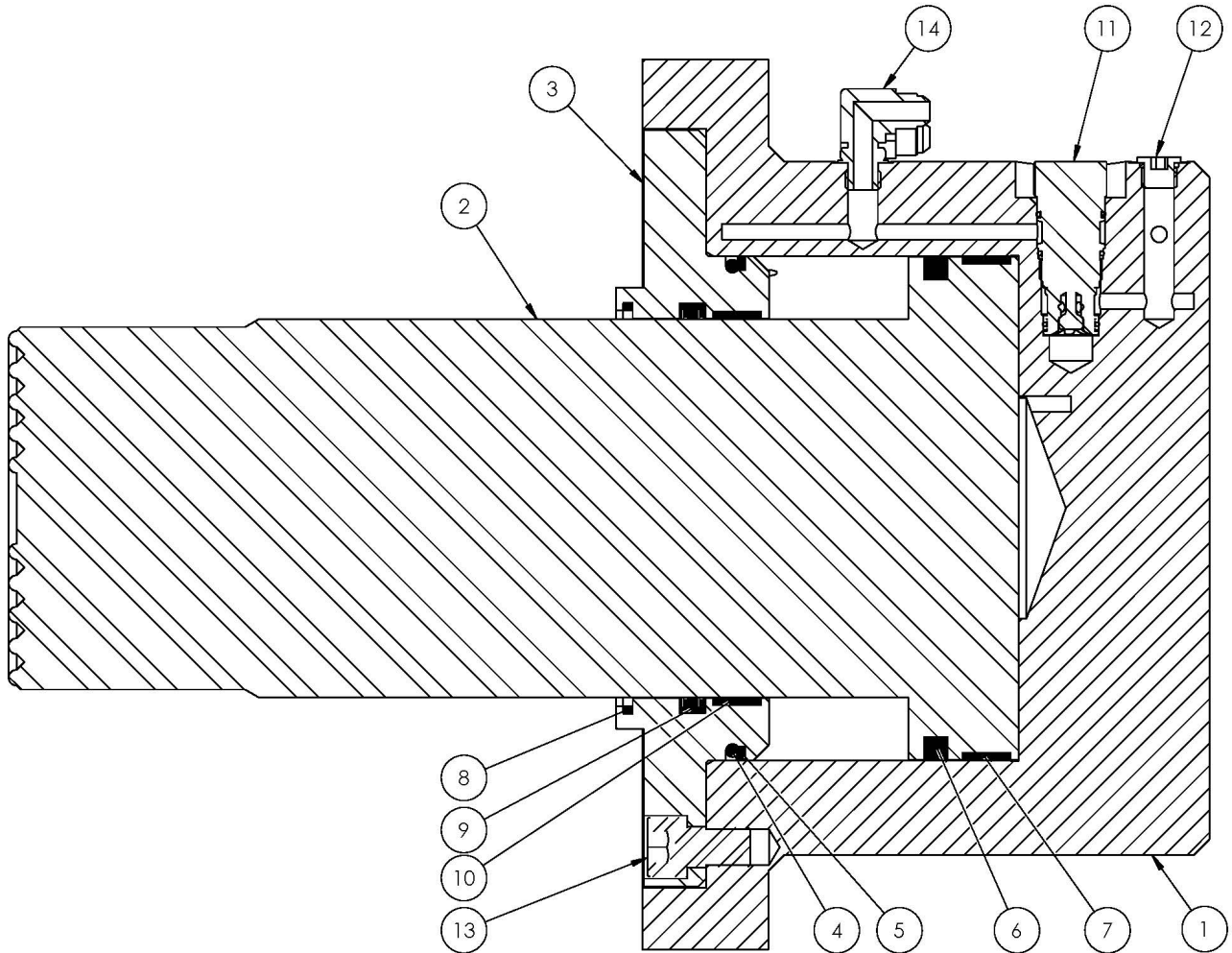


Figure 2-G Caisson Clamp Cylinder Asm Identification

Item	Qty	Description	Part #
1	1	8" Hyd Cyl Barrel	#1001409
2	1	Caisson Piston and Rod	#250003
3	1	Front Seal Plate	#222004
4	1	2-367 O-Ring 90 Duro	#222018
5	1	8-367 Par Back	#222017
6	1	Piston Ring and Expander	#1004540
7	1	Piston Wear Band	#1004541
8	1	Rod Wiper	#1004852
9	1	Rod Seal	#1004542
10	1	Rod Wear Band	#222014
11	1	PO Check Valve	#222016
12	1	#6 SAE O-ring Plug	#1003959
13	12	SHCS 5/8-18 UNF X 1.00 Lg	#1003804
14	2	Fitting-6SAE / 6JIC 90 Deg-3/8	#222015

Table 2-G Caisson Clamp Cylinder Asm Identification



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II. MAJOR COMPONENT DEFINITION (Continued...)

II-8. Tool Set Identification.

Mounted inside the **Model 350 Power Unit** is a set of tools frequently used for the maintenance of the **APE Model 150/150T Vibratory Driver**. The following figure and table shows the location and the use for each tool.

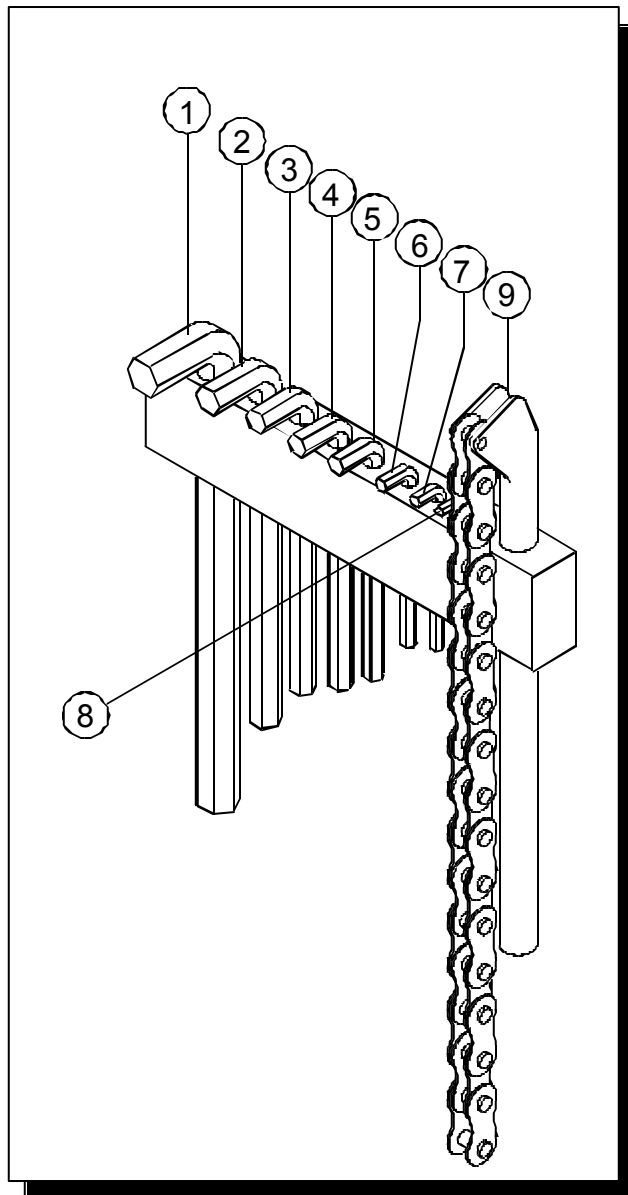


Table 2-E. Tool Set Identification.

ITEM	QTY	DESCRIPTION	PART#
1	1	1" Allen Wrench	#50004
For use with the clamp attachment bolts			
2	1	3/4" Allen Wrench	#50006
For use with clamp fixed jaw, sheet guide			
3	1	5/8" Allen Wrench	#95007
For hydraulic motor, drain plug, top plate			
4	1	9/16" Allen Wrench	#50013
For use with the hose bracket bolts			
5	1	1/2" Allen Wrench	#50008
6	1	3/8" Allen Wrench	#50009
For use with bearing cover bolts			
7	1	5/16" Allen Wrench	#50014
For use with the hose bracket bolts			
8	1	1/4" Allen Wrench	#50015
For use with the vibro oil level check			
9	1	Chain Wrench	#50011
Used to tighten the quick disconnects			

Figure 2-H Tool Set Identification.



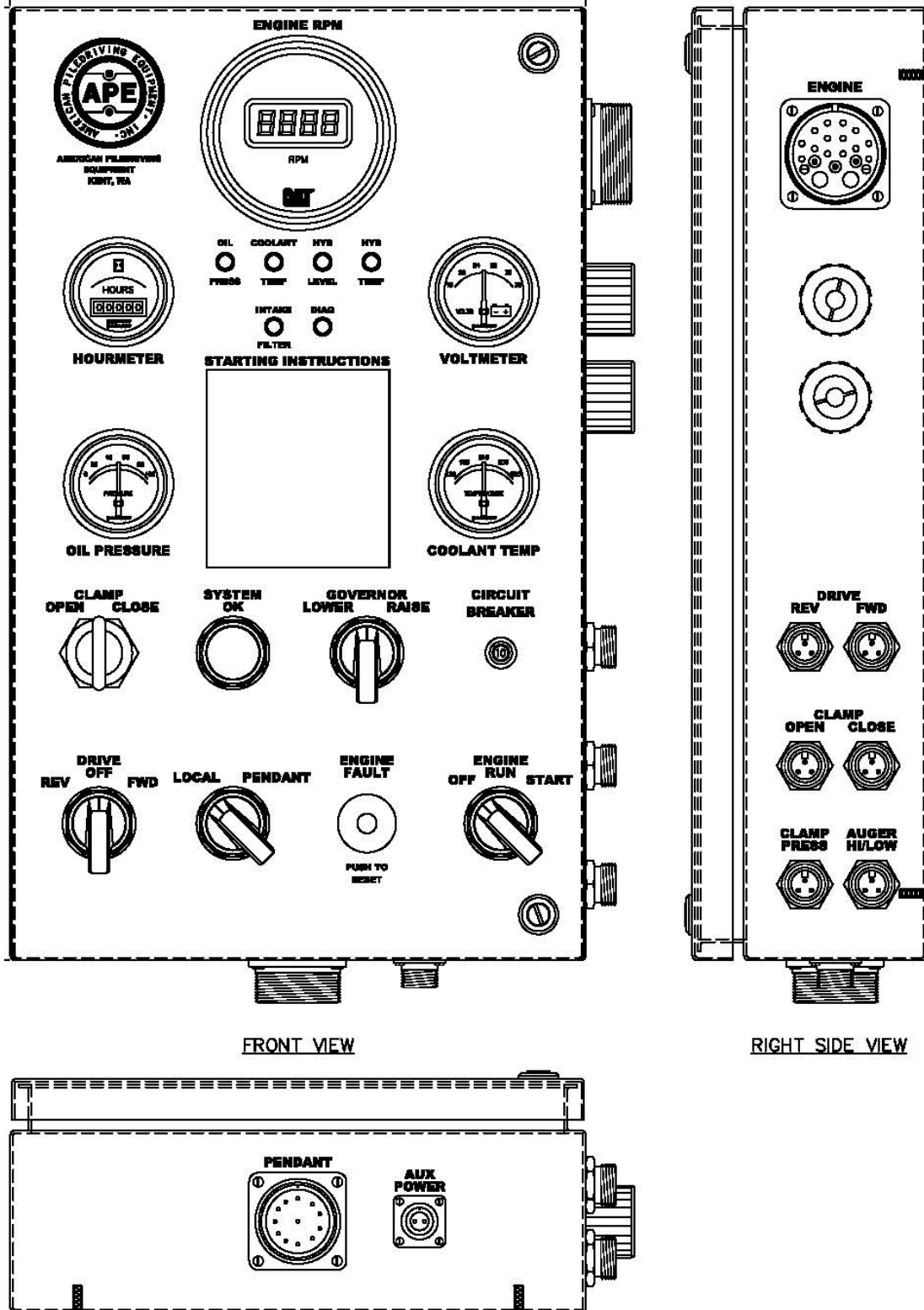
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II. MAJOR COMPONENT DEFINITION (Continued...)

II-9. Control Panel Identification



FRONT VIEW

RIGHT SIDE VIEW

Figure 2-I Control Panel View

II. MAJOR COMPONENT DEFINITION (Continued...)

II-10. Control Panel Schematic

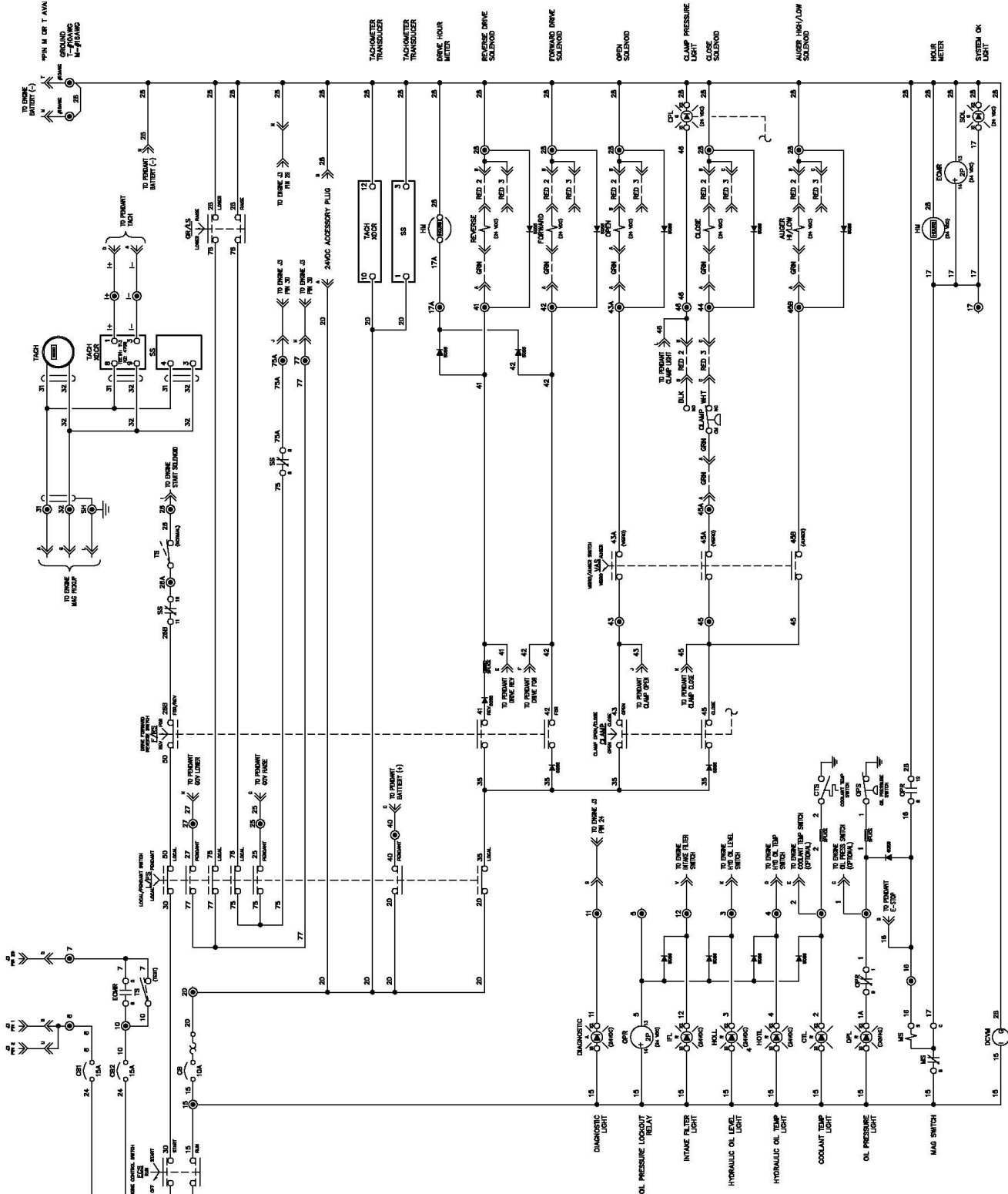


Figure 2-J Control Panel Schematic



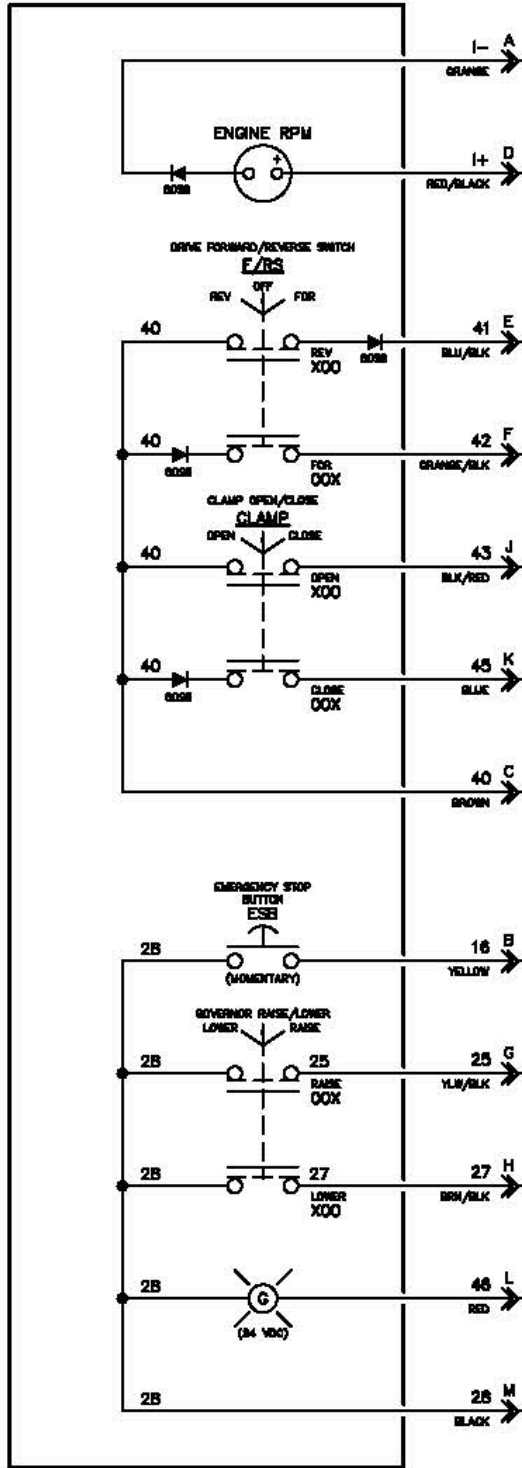
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MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

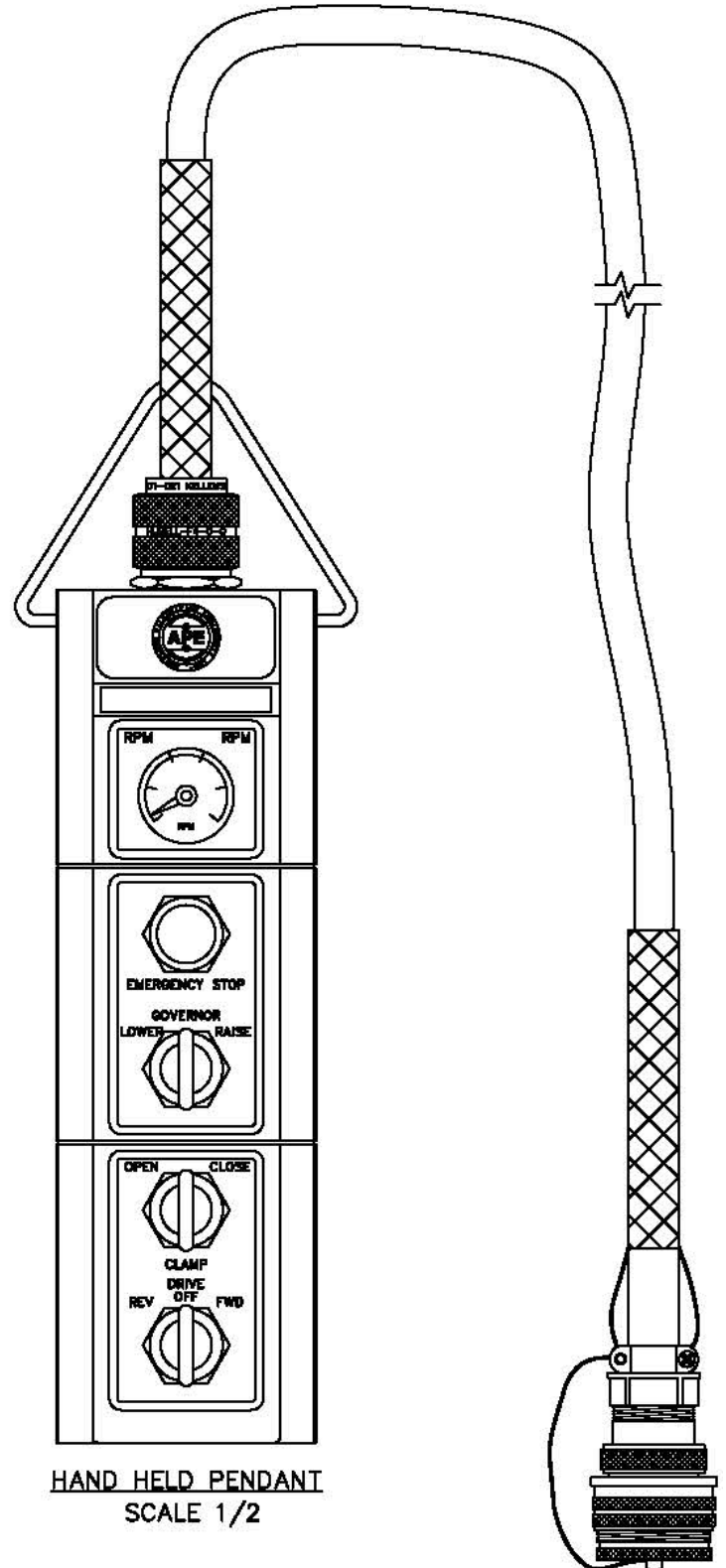
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II. MAJOR COMPONENT DEFINITION (Continued...)

II-11. Pendant



SCHEMATIC DIAGRAM



**HAND HELD PENDANT
SCALE 1/2**

Figure 2-K Remote Pendant



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MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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III. LOADING AND UNLOADING

III-1. Model 150/150T Vibratory Driver.

The APE 150/150T vibrators are normally shipped in travel stands. Two sliding pins release the vibrator from the stand. To re-install, set vibro in stand and slide pins inward and rotate. Hoist vibro and stand by rigging to the vibro lifting shackle. Vibrators shipped without stands are usually laid flat on the trailer deck and the hose bundle is coiled on top. Lift the vibrator by rigging one line to the lifting shackle and one line around the clamp attachment lifting the vibro and hose bundle as one load. Avoid smashing hydraulic lines. Vibro should be loaded with hydraulic motors down facing the deck and breather valves facing the sky. Before the truck has left, carefully inspect the machine and hoses for any missing equipment or sign of damage that may have occurred during shipment or unloading.

III-2. Model 350 Power Unit.

The Power Unit is always loaded with the oil cooler facing to the rear of the truck to prevent damage to the cooler and the radiator from flying objects. The Power Unit is usually held to the truck by wrapping a chain around both ends of the fuel tank base and the truck bed. After loading the Power Unit, tape the exhaust rain cap shut to prevent rain water from getting inside. If quick disconnects do not have safety cables then store them under the panel in the storage box rather than risk the possibility of the caps and plugs coming loose and falling off into traffic. Make sure all doors are fully closed. Tighten fuel cap to prevent diesel fuel from washing out the fill spout.

III-3. What to do if damaged during shipment.

In the event of damage, notify the trucking agent at once. Note all damage on the bill of lading. Fax the information as soon as possible, any delay may make it impossible to find the responsible party.



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IV. PREPARATION AND OPERATION

IV-1. Rigging of Vibratory Driver

A steel wire rope sling must be connected to the lifting bail located on top of the vibro. The required strength of this sling depends on the capacity of the crane and the work to be carried out. A safety factor of six is recommended. Several turns of a smaller diameter cable will result in a longer lasting sling than one larger diameter cable. When making a sling, avoid using cheap cable clamps. Check the clamps daily.

IV-2. Installing the Clamp Attachment

The Vibro is fitted with a standard sheet clamp at the factory. However, several types of clamps are used on APE vibros to fit many different types of piles. A step by step procedure is provided as follows:

- 1.) Clean all drilled and tapped threads on the bottom surface of the gearbox. Use a 1 1/2"UNC tap to clean any rusted threads and blow out any remaining fragments with compressed air. If there is a cutting torch on the jobsite then use the oxygen setting to blast the threads clean. Hold a rag over the tapped hole to prevent flying dirt from blasting into your eyes.
- 2.) Clean the machined bottom surface of the gearbox and prepare to mount the clamp. If the clamp bolts should ever break, check the machined surface with a straight edge to make sure it is true and flat.
- 3.) Clean the machined surface of clamp. Eye-ball the entire surface for damage. Make sure the surface is flat and void of all dirt.
- 4.) Start by getting the center bolt in first and work outwards. Do not tighten bolts until you have all of the bolts started.
- 5.) Tighten bolts using a six-foot cheater pipe. If you do not have a cheater pipe then use a sledge hammer.
- 6.) Go around all bolts at least three times making sure they are tight.
- 7.) After vibrating the first pile, check the bolts again.
- 8.) If one bolt breaks, replace them all since they may be weak or cracked.
- 9.) Never operate the vibro with missing clamp bolts.

WARNING: Do not use grade five bolts. All bolts should be allen head cap screw bolts. If one bolt breaks then the others are damaged and must be replaced. Never drive piles if one bolt is broken. Bolts break only because they were not tight and the crew neglected to check them. A good operator insists that every bolt is checked twice daily.



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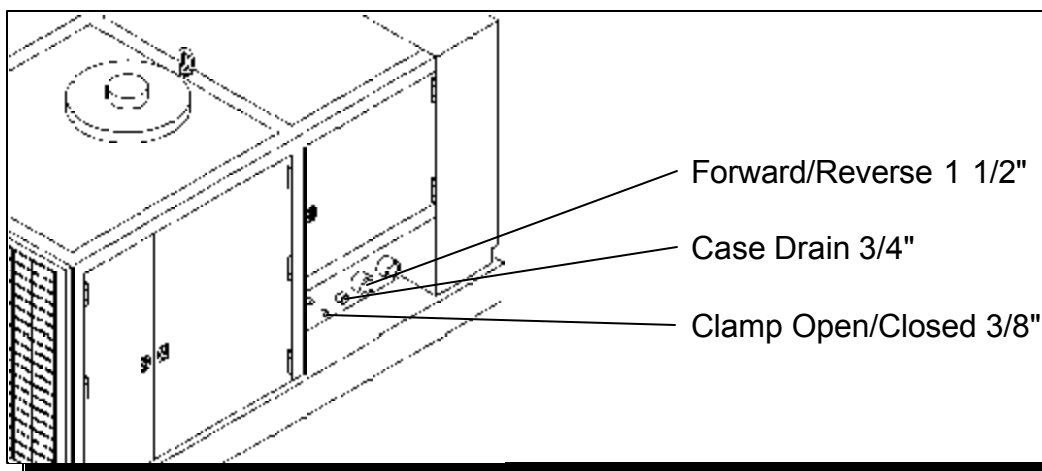
IV. PREPARATION AND OPERATION (Continued...)

IV-3. Plumbing the Vibro Hoses to the Power Unit.

There are five hoses leading from the vibro that must be connected to the power unit to begin operation (Please see Hose Identification Figure 2-B on page 2-4). There are two big hoses, two little hoses and one middle sized hose. The hoses attach to the power unit by screwing the quick dis-connect couplers onto the proper couplers of the power unit. The couplers on the power unit are mated with the couplers on the vibro so there is no chance of putting them on backwards. Please take the following steps when installing the couplers:

WARNING: TURN THE POWER UNIT OFF BEFORE INSTALLING COUPLERS

- 1.) Turn the power unit OFF.
- 2.) Clean all couplers with a can of ether if available. A clean dry cloth will also work but will require extreme care. Fittings must be spotless clean.
- 3.) Install couplers by screwing them onto their respective counterparts. Try to avoid cross-threading and maintain a straight line. Jerk the hose back and forth while turning coupler to aid installation effort. **Push hard to get the big coupler threads started.**
- 4.) Make sure fittings are tight. If they are properly cleaned they should run up tight with just a firm hand grip. However, they should be double checked with a chain wrench.
- 5.) Avoid over-tightening.
- 6.) If near salt water, spray with a light oil to prevent oxidation.
- 7.) Position the Power Unit so that vibrator has enough hose to reach the work. Avoid pulling on the hoses. Most hose failures are caused by pulling hoses off couplers.





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IV. PREPARATION AND OPERATION (Continued...)

IV-4. Filling Vibrator Pressure Hose.

The vibrator is shipped with the hoses filled with oil. However, if the unit has been sitting for a long period of time or if a damaged hose has been replaced with a new one, then the hoses must be filled. Hook up all the hoses to the power unit (Please see Power Unit Hose Connections Figure 4-A on page 4-2). Start the power unit and let it run for ten minutes before running the vibro. The hoses will fill up by themselves in ten minutes even if the vibro is not in the vibrate mode.

IV-5. Bleeding the Clamp Attachment Hydraulic Hoses.

If the opening and closing of the jaws seems spongy or slow, it may be a result of air in the clamp hoses. Normally there is no need to worry about bleeding the clamp lines because the unit is shipped fully tested. However, should the vibro sit for a long period of time, if a new attachment is being installed or if a damaged clamp hose has been replaced, then the system may require bleeding to remove unwanted air in the system. To bleed the clamp system, follow the following steps:

- 1.) Shut Power Unit OFF.
- 2.) Make sure the clamp line quick dis-connects are coupled to the power unit.
- 3.) Start the power unit engine and run at 1500 rpm. Give the engine time to warm up.
- 4.) Loosen the clamp lines at the hydraulic cylinder by backing the fittings off just a little.
- 5.) Turn the clamp switch on the power unit control pendant to "CLOSE" and wait for oil to flow from the fittings. WATCH FOR AIR BUBBLES. When air bubbles have stopped then quickly re-tighten the fittings.
- 6.) Repeat the same procedure for "OPEN" side.
- 7.) Operate the jaws. If they are still a bit spongy then repeat bleeding steps once more.

WARNING: DO NOT BLEED SYSTEM AT FULL ENGINE THROTTLE BECAUSE TOO MUCH OIL WILL FLOW FROM THE HOSES AND COULD CAUSE INJURY.

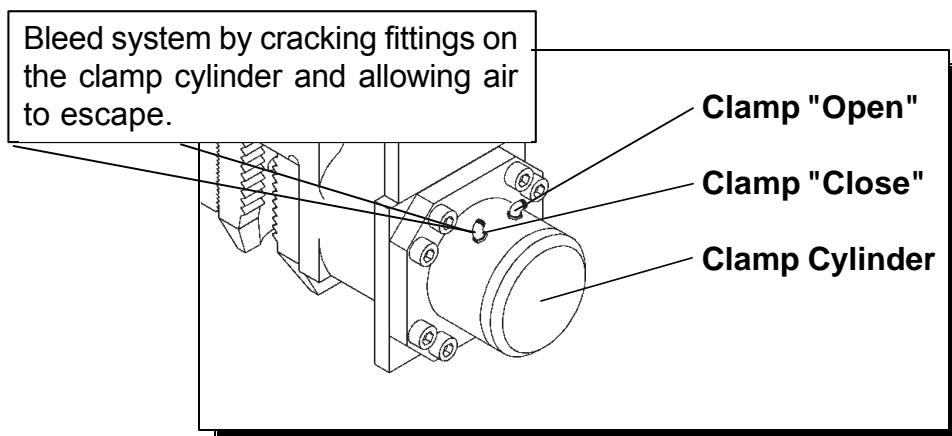


Figure 4-B. Bleeding Clamp Attachment



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IV. PREPARATION AND OPERATION (Continued...)

IV-6. Precautions and Rules for Operation.

The following is a list of precautions, suggestions and rules that are intended to help promote the safe and productive use of the APE Model 150/150T Vibratory Driver.

- 1.) Follow the Daily Maintenance Required Prior to Operation, [Section V-1.] [page 5-1].
- 2.) Read and follow the Safety Precautions, [page iii].
- 3.) Follow the start-up procedures listed in the manual for the power unit being used.
- 4.) Start with piles in good condition.
- 5.) Put all teeth in pile.
- 6.) Drive in steps eight feet or less.
- 7.) Keep sheets plumb.
- 8.) Come up to speed before doing work.
- 9.) No dancing. Avoid densifying the soil.
- 10.) Drive past obstacles and then go back.
- 11.) Backhoe on site to remove obstacles.
- 12.) Lead with the ball.
- 13.) Probe the pile if it appears stuck.
- 14.) Keep piles plumb or down the road you go.
- 15.) Never rush the sheet pile foreman.
- 16.) Slow and plumb and the job will get done.
- 17.) Melted inner locks - piles out of plumb.
- 18.) Never stand under pile drivers.
- 19.) Low clamp pressure means jaw failures.
- 20.) Wait for vibro to get to full speed then pull.
- 21.) Don't over excavate - lower the ring.
- 22.) Look at the jaws during driving.
- 23.) Beware of cracked or broken sheets.
- 24.) In sandy soils drive faster. Vibration can cause settlement in loose, granular soils.
- 25.) In clay amplitude is everything.
- 26.) Low drive pressure means easy work.
- 27.) High pressure means friction on piles.
- 28.) Over 5000 psi means get a bigger vibro.
- 29.) No amplitude means get a bigger vibro.
- 30.) Caissons need heavy wall to avoid flex.
- 31.) Check clamp bolts each morning.
- 32.) Read the manual - know your machine.
- 33.) Attach whip line to pile when pulling.
- 34.) Know your line pull.
- 35.) Extract straight - look at boom and cable.
- 36.) Give boom stops some room.
- 37.) Stalled engine means dirty fuel filters.



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IV. PREPARATION AND OPERATION (Continued...)

IV-7. Relief Valve Settings Prior to Operation - Model 350

The Relief Valve and Pressure Switches are set by the factory. They will need to be re-set if the pressure switch is replaced.

1. Do not hook up quick disconnects. Start and warm engine . Bring to full rpm.
2. Check Clamp relief valve setting. On the Control Panel, turn the clamp switch to "OPEN" and hold it there while you read the CLAMP OPEN GAUGE on the panel. It should read 4800 PSI. If it is not coming up to pressure, then set the relief valve (FACTORY AUTHORIZED PERSONNEL ONLY), by loosening the lock nut and turning the knob in slowly until the proper pressure is reached. Turn in (CW) to increase pressure, and out (CCW) to decrease pressure. Tighten the locknut and recheck the pressure to make sure that the setting did not move during tightening the lock nut. When the clamp switch is turned to "OPEN" and held, a small light on the solenoid is illuminated, showing that there is power to the solenoid. Otherwise, the light on the solenoid should be off.

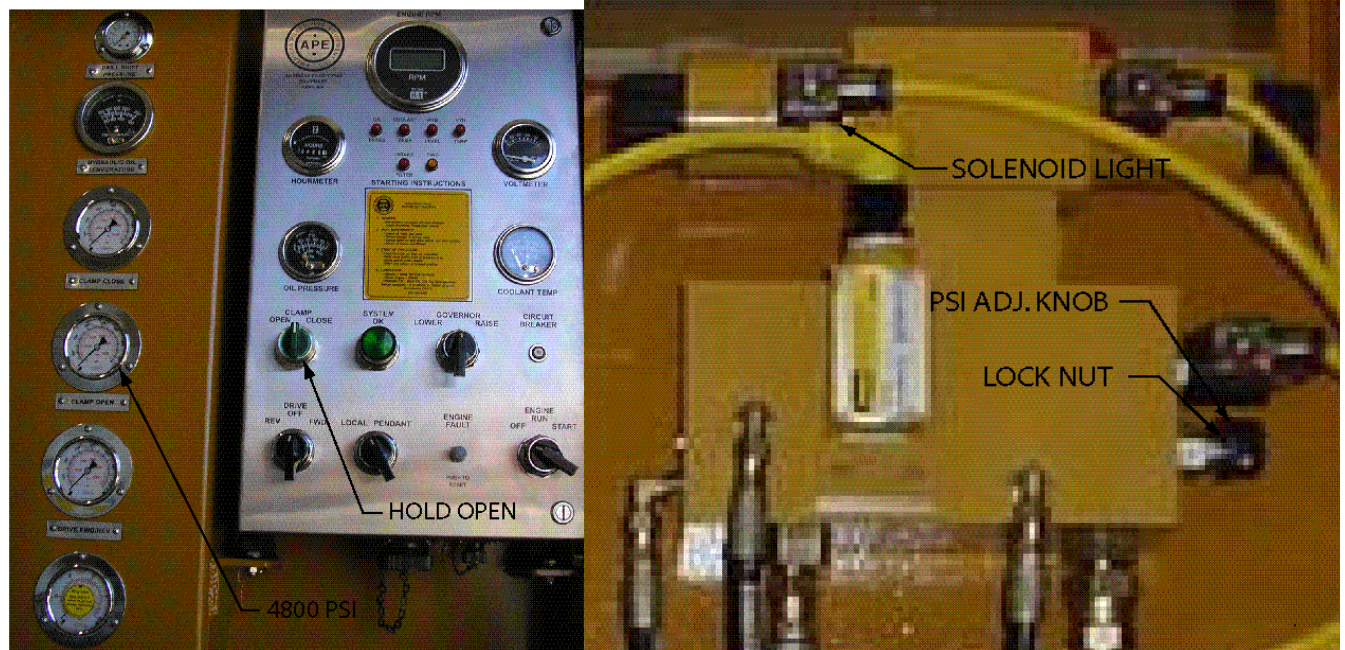


Figure 4-C. Setting Relief Valve

IV. PREPARATION AND OPERATION (Continued...)

IV-7. Relief Valve Settings Prior to Operation - Model 350 (Continued...)

3. Check the clamp pressure switch setting. Turn the clamp to "CLOSE". If there is proper clamp pressure the CLAMP CLOSE GAUGE should read 4500 PSI to 4800 PSI, and the GREEN LIGHT comes on (see figure 4-D.)

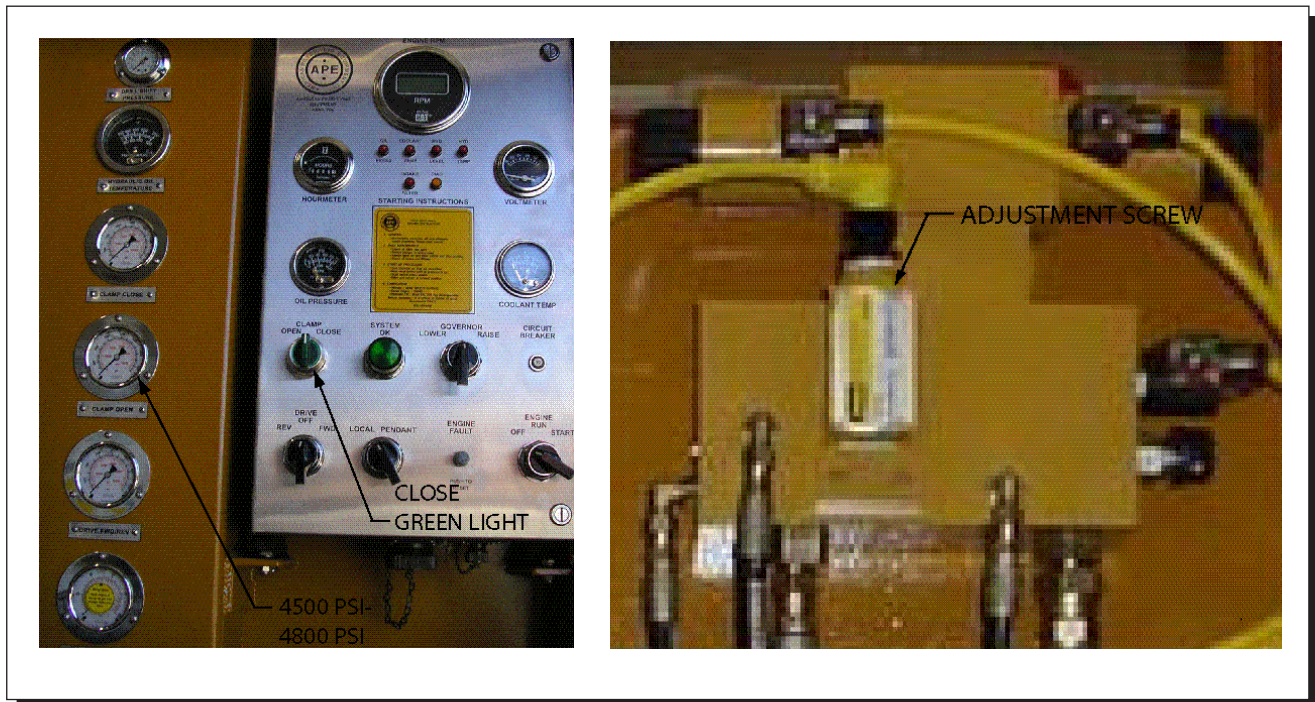


Figure 4-D. Checking Clamp Pressure Switch Setting

4. Adjust the clamp pressure switch setting. (If necessary). To set the pressure switch, turn the adjustment screw out using a screwdriver. (Turn it out a few turns counter-clockwise.) Turn clamp switch to "OPEN" for a second. Make sure the CLAMP OPEN GAUGE reads 4800 PSI. If it does not, then go back to the Step 2 and set the clamp relief valve first

With clamp relief set at 4800 PSI, turn the clamp switch to "CLOSE". Green light should be on and clamp pressure should be very low or not reading at all.

Turn Adjustment Screw in (CW) until the green light goes off. Then, turn adjustment screw out (CCW) until green light comes on. (About 1/4 to 1/2 turn.) The CLAMP CLOSE GAUGE should read 4000 to 4800 PSI.

To check, turn clamp switch to "OPEN". The green light should be on.

Repeat procedure if necessary.



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IV. PREPARATION AND OPERATION (Continued...)

IV-8. Shut-down Procedures.

The following procedures explain what to do with the power unit to correctly shut down the APE Model 200 Vibratory Driver.

- 1.) Stop the vibrator. (Refer to the power unit operating manual .)
- 2.) Allow the diesel engine to run for five minutes at 1000 engine rpm
- 3.) Reduce engine speed to low idle for about 60 seconds.
- 4.) Shut engine off by turning off the main power switch.

WARNING: Do not shut the power unit engine down while the vibrator is clamped onto a pile. The clamp check valve will slowly bleed off if there is any leakage in the hose lines or worn clamp seals in the cylinder that moves the jaw open or closed.



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IV. PREPARATION AND OPERATION (Continued...)

IV-9. Operation of the Control Pendant.

1. All functions of the vibro can be controlled by the control pendant. It is the choice of the crew as to where best to locate the control pendant. Some prefer that the crane operator control all functions. Others prefer to give it to one of the ground crew so it can be positioned close to the work at hand. A 50 foot (15.2 M) cord is provided as standard equipment. If this is not long enough, additional 50 foot (15.2 M) sections can be added. Should the control pendant become damaged, all functions can be manually operated. See page 7-16 in this manual for more details on operation. See page 2-14 of this manual for wiring diagram and control pendant components.

IV-10. Normal steps to operate vibrator:

(Note: In order to operate power unit, Drive must be "OFF").

1. Position vibro on pile.
2. Set power unit speed to full throttle (factory set 2050 RPM).
3. Turn Clamp to "CLOSE" the switch will stay in the "CLOSE" position and wait for light to come on.
4. Turn Drive to "FWD" to direct hydraulic oil to Vibro.
5. To drive piles, lower crane line as vibro vibrates pile.
6. To extract, pull up on vibro while vibrating.
7. See "Precautions and Rules for Operation" in this manual for more detailed operations on driving and extracting piles.
8. To stop the vibro turn Drive to "OFF".
10. To release clamp, turn clamp switch to "OPEN" clamp light will turn off. Once the jaws are open release the switch.

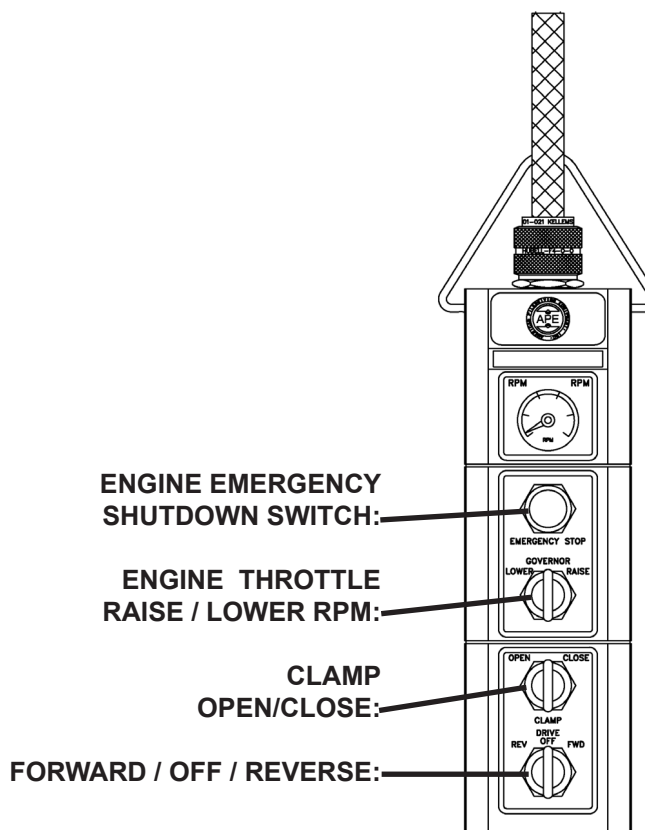


Figure 4-E. Control Pendant



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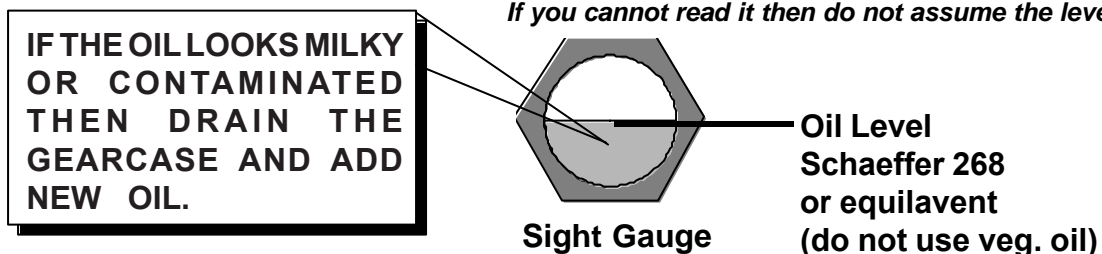
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V. MAINTENANCE

V-1. Daily Maintenance Required Prior to Operation.

- 1.) Visually inspect the entire vibro for loose nuts or bolts. Put a wrench on the clamp bolts and check them for tightness.
- 2.) Grease the Jaw Plunger on the clamp housing.
- 3.) Check the oil level in the vibrator. Hang vibro from crane and look at sight gauge. Make sure the oil is half way up gauge. If you cannot read it then you can't run the vibro. Remove the gauge and clean it by spraying a shot of starting fluid at it. **YOU MUST KNOW THE LEVEL!**



- 4.) If the oil is milky or contaminated then change it. **Change the oil every 75 hours.**
- 5.) Check the fluid level in the power unit hydraulic tank.
- 6.) Look at all the hoses. Check for cuts or other damage that might cause an oil leak.
- 7.) Check the rubbers in the suppressor housing. Look for cracks.
- 8.) **Check the following items:**

Check water level in radiator	Check engine oil
Check battery level	Check hydraulic return filter indicator
Check fuel level	Check fan belts on engine
Check oil level in pump drive	Check entire unit for hydraulic leaks
Check hydraulic oil level	Check condition of jaws before operating

V-2. Checklist After Power Unit Engine Has Started

- 1.) Check all hydraulic hoses for leaks. Make sure they hang free with no kinks.
- 2.) Check inside the Power Unit. Look at all hoses and valves, check for leaks.
- 3.) Check filter indicator with engine running at full rpm. Replace if necessary.
- 4.) Check wire rope sling and make sure it is in excellent condition.
- 5.) Check jaws for wear. Replace if necessary.
- 6.) Close jaws, make sure clamp light comes on.



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V. MAINTENANCE (Continued...)

V-3. Maintenance and Adjustments. (75 Hours)

Change the oil in vibrator gearbox. Remove the drain plug from bottom of gearbox and drain the oil into a bucket. Check oil for any metal shavings. Replace oil in gearbox by adding 3.5 gallons of standard weight oil. Schaeffer 268.

Clean the gearbox breathers each time the oil is changed. Replace the breathers if necessary.

V-4. Maintenance and Adjustments. (Eccentric Bearings)

1.) Model 150/150T - The Eccentric Bearings should be checked and/or replaced after every 2500 hours of operation.

V-5. Maintenance and Adjustments in Severe Conditions.

When average temperature is above (80 deg. F) or below (-1 deg. F) reduce servicing intervals to one half of those specified above.

When operating in the presence of dust or sand, reduce servicing intervals to one-third of those specified.

During stand-by or inactive periods, the servicing intervals may be reduced to one-half. The unit should be run every 30 days or less to keep internal parts lubricated.

V-6. Lubrication

V-6A. Lubrication - Vibratory Gearbox.

The Gearbox oil should be changed when milky. Schaeffer 268 or equal is the preferred oil. The gearbox requires 3.5 gallons of oil.

V-6B. Lubrication - Clamp Attachment.

The Clamp Attachment hydraulic oil must be checked and changed on a regular basis. The Clamp Cylinder Plunger should be checked for rust and debris. Lubricate the plunger on a regular basis using the grease fitting on the side of the clamp housing .



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V. MAINTENANCE (Continued...)

V-7A. Filters, Fluid Types and Capacities

FILTERS

LOCATION	ENGINE	FILTER TYPE	QUANTITY
Engine Oil:	Caterpillar C9	Caterpillar #1R-1808	1
Engine Fuel:	Caterpillar C9	Caterpillar #1R-0751	1
Eng. Fuel Water Sep:	Caterpillar C9	Caterpillar #1R-0771	1
Air filter Inner:	Caterpillar C9	Caterpillar #1R-132-7167	1
Air filter Outer:	Caterpillar C9	Caterpillar #6I-2510	1
Hyd. Oil Filter:		Zinga	2
Hand Pump Filter:		Zinga	2

Table 5-A. Power Unit Filters

OIL TYPES AND CAPACITIES

LOCATION	ENGINE	OIL TYPE	CAPACITY
Hydraulic Oil-Main:	-----	Terresolve 146	300 gallons
Hyd Oil-Reserve:	-----	Terresolve 146	55 gallons
Engine Oil:	Caterpillar C9	SAE 15W40	40 quarts
Engine Water:	Caterpillar C9	See note below	27 gallons
Fan Drive:	Caterpillar C9	Multi-Purpose Grease	as needed
Pump Drive:	Durst	Schaeffer 268	2 gallons
Fuel Tank:	-----	Diesel	140 gallons
GearBox:	-----	Schaeffer 268	3.50 gallons

Caterpillar Extended Life Anti-freeze p/n 119-5150 mix with water 50/50.

Caterpillar Extended Life Anti-freeze p/n 101-2844 premixed.



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V. MAINTENANCE (Continued...)

V7-B. Hydraulic Fluid

When adding or changing hydraulic fluid APE uses only Terresolve Invirological 146 Hydraulic fluid which is non-toxic and will not harm soil or water and is biodegradable. Consult your local oil supplier for recommendations on mixing hydraulic oils. Change hydraulic oil if it looks milky. This includes all hydraulic lines leading to and from the vibro. Milky oil indicates that water is in the oil.

V7-C. Two Part Hydraulic Fluid Tank

The Hydraulic Tank is a two part tank. The main tank which the pumps feed from, cooled and filtered oil returns. The upper tank is an auxiliary tank to store extra or surplus hydraulic oil. Hydraulic oil may be transferred from the auxiliary tank to the main tank.

There is a valve on the bottom of the main hydraulic tank that should be opened into a bucket periodically before the engine is started. Water that may get into the system will settle to the bottom of the hydraulic tank, opening this valve will allow that water to be removed from the system.

V7-D. Draining and Filling Hydraulic Fluid Tank

- 1.) Shut down power unit by turning off the diesel engine.
- 2.) Place warning tag on control panel so that no one mistakenly starts the unit while tank is not operational.
- 3.) Remove cap and open drain valve located on bottom of main hydraulic tank. When tank is empty we recommend opening side cover(s) to confirm the tank is clean inside.
- 4.) Replace covers, close drain valve and replace cap.
- 5.) Refill using hand pump and filter.
- 6.) Prime both the clamp and the main pump before restarting.
- 7.) Take extreme caution that no dirt or other unwanted particles enters the system.



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V. MAINTENANCE (Continued...)

V-7E. Changing Hydraulic Return Filter Element

The hydraulic return filters are mounted to dual head adapters on the hydraulic tank inside the power unit. They are mounted high on the tank so that when the filter elements are removed the oil will not drain from the hydraulic tank. The filter adapter has a gage at the control panel to tell you when it is dirty. When the hydraulic oil is above 80 degrees F and the return filter gauge reads 50 PSI it is time to change the filters.

V-7F. Steps to Remove the Hydraulic Filter Elements

- 1.) Shut down power unit by turning off the diesel engine.
- 2.) Place warning tag on control panel so that no one mistakenly starts the unit while filters are being changed.
- 3.) Clean area around filters so that when they are removed there is no chance of introducing dirt into the hydraulic system.
- 4.) Using a filter wrench, turn the filter counter clockwise and spin the filter off of the filter housing.
- 5.) Install new clean filter making sure the o-ring is in place.
- 6.) Always change all four filters at the same time.



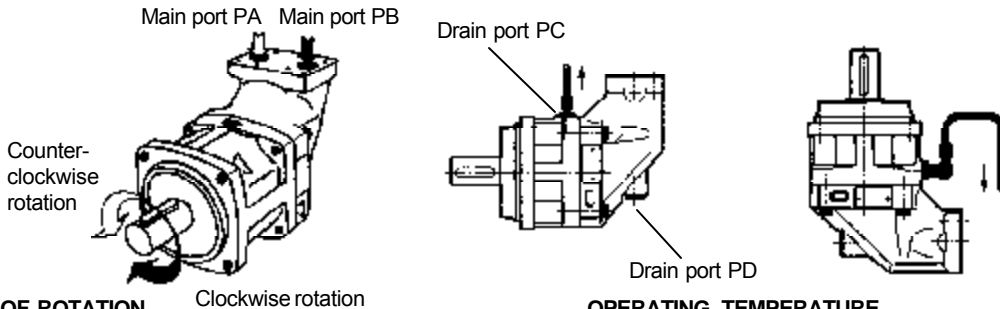
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V. MAINTENANCE (Continued...)

V-8. Hydraulic Motor - Installation and Start-Up. - Figure 5A.



DIRECTION OF ROTATION

The F12 motor is bi-directional. The picture shows direction of flow vs. shaft rotation. When fluid enters port **PB** (black arrow) the motor turns counter clockwise, and when port **PA** is pressurized (open arrow) the shaft turns counter clockwise.

The F12 pump rotates clockwise or counter clockwise. The ordering code shows the direction of rotation.

FILTRATION

To obtain maximum motor service life, the fluid cleanliness should be checked to meet ISO code 18/13 or better (ISO 4406). A 10 um (absolute) filter is recommended.

REQUIRED INLET PRESSURE

The motor sometimes operates as a pump (e.g. when it is used in a propel transmission and the vehicle is going downhill). The motor inlet port must then be supplied with sufficient fluid pressure, or increased noise and deteriorating performance may otherwise be experienced.

CASE PRESSURE

The table shows the highest recommended case pressure (F12 shaft seal type **H**) as a function of shaft speed. To obtain the longest seal life, the case pressure should be limited to 50% or less of the figures shown.

NOTE: Contact VOAC Hydraulics for information on other shaft seals.

Motor designation	Motor case pressure [bar] vs. shaft speed [rpm]				
	1500	3000	4000	5000	6000
F12-30	14.0	7.0	5.5	4.5	3.5
F12-40	12.0	6.0	4.5	3.5	
F12-60	12.0	6.0	4.5	3.5	
F12-80	10.0	5.0	4.0		
F12-110					

CASE DRAIN CONNECTIONS

There are two drain ports (**PC** and **PD**). The uppermost drain port should be utilized. In mounting positions such as 'shaft up', a drain line loop can be formed to provide bearing lubrication and cooling. Preferably, the drain line should be connected directly to the tank to avoid excessively high case pressure.

NOTE When the motor is operating, the case must be filled with fluid to at least 50%.

OPERATING TEMPERATURE

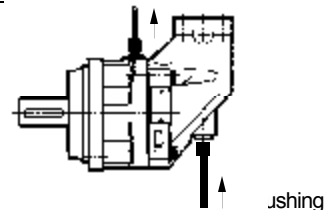
The following temperatures should not exceed (type **H** seal):

System fluid: 80deg. C
Drain fluid: 100deg. C

Type **V** ('Viton') shaft seals can be used to 115deg. C.

Continuous operation may require case flushing in order to meet the above viscosity and temperature limitations. The table shows operating speeds, above which flushing is usually required, as well as suggested flow through the case.

Motor designation	Speed [rpm]	Flow [l/min]
F12-30	3500	4-8
F12-40	3000	5-10
F12-60	3000	7-14
F12-80	2500	8-1 ^e
F12-110	2300	9-1



BEFORE START-UP

Make sure the motor case as well as the entire hydraulic system is filled with a recommended fluid. The internal leakage, especially at low operating pressures, is not sufficient to provide lubrication at start-up.

HYDRAULIC FLUIDS

Ratings and performance data for series F12 are based on operating with good quality, contamination-free petroleum-based fluids, Hydraulic fluids type HLP (DIN 51524), automatic transmission fluids type A, or API CD engine oils can be used.

At operating temperature, the viscosity (of the drain fluid) should normally be kept above 8 mm²/s (cSt). At start-up, the viscosity should not exceed 1000 mm²/s.

Fire resistant fluids, when used under modified operating conditions, and synthetic fluids are also suitable. Contact VOAC Hydraulics for further information.



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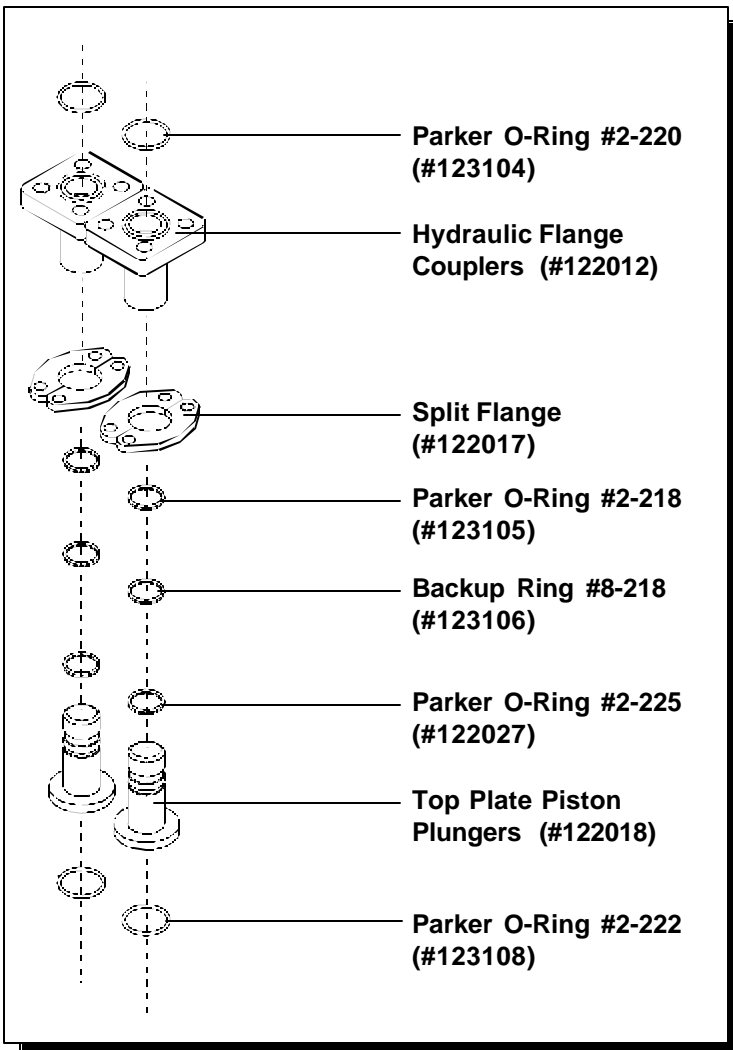
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V. MAINTENANCE (Continued...)

V-9. Hydraulic Motor Coupling Assembly.

The APE Hydraulic Motor Coupling Assembly allows the hydraulic fluid to flow between the rifle bored top plate of the vibro gearbox and the hydraulic motors. The following steps should be followed when removing and installing the hydraulic motors or if dis-assembly is required for maintenance of the coupling assembly:



Coupling Removal and Re-assembly:

1. Remove the bolts holding the "Split Flange" to top of the motor.
2. Loosen the 4 bolts which connect the "Hydraulic Flange Couplers" to the bottom of the gearbox top plate.
3. Screw the "Hydraulic Flange Couplers" and the "Top Plate Piston Plungers" together (This will decrease the overall size of the assembly and allow easier removal of the components).
4. Watch for oil flowing out from the openings on the under side of the top plate. Insert a clean rag into the openings to block the oil flow and to prevent debris from entering the opening and contaminating the hydraulic oil.
5. Reverse the procedure for re-assembly. At assembly, make sure the hydraulic motor is parallel to the top plate by verifying both sides with a tape measure. If necessary, loosen the 4 bolts holding the motor to the gearbox face and shift the motor until the top plate and motor machined face are parallel.

Figure 5-B. Hydraulic Motor Coupling Assembly.



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V. MAINTENANCE (Continued...)

V-10. Pump Drive.

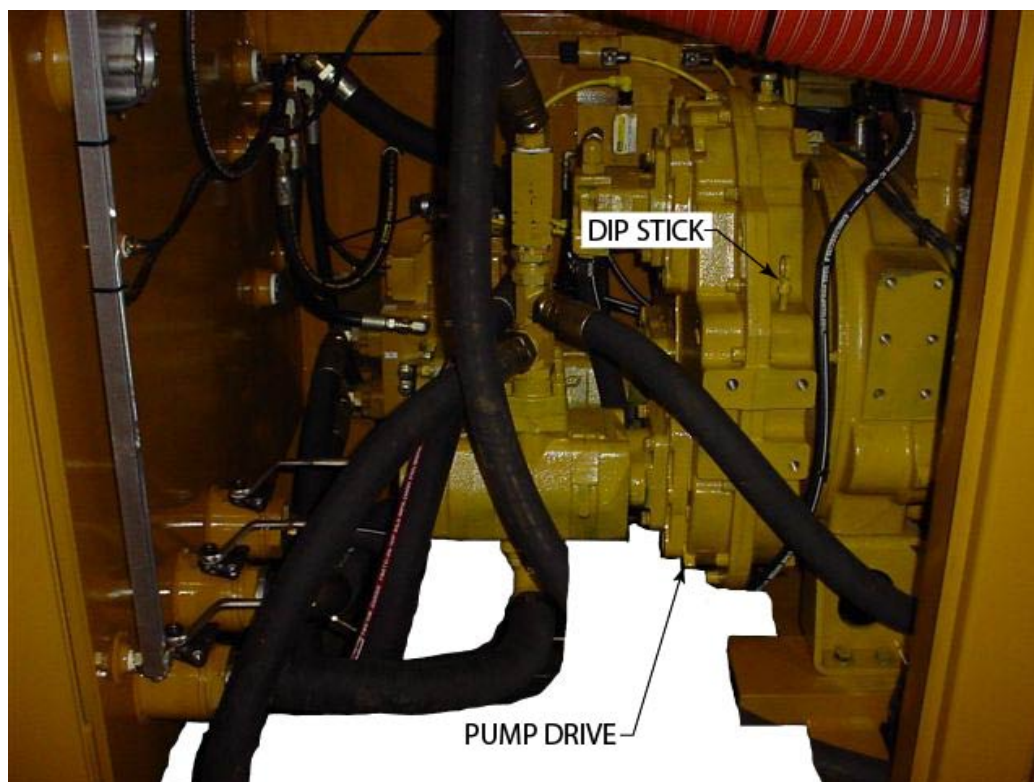


Figure 5-C. Pump Drive

The pump drive used on the APE 350VM power unit is a gear box that requires lubrication. The main gearbox takes about 2 gallons of oil. Check the level using the dip stick.

Oil changes are suggested every six months or 1000 hours, which ever occurs first.

Fill with Schaeffer 268. Before operating the unit, check the oil level dip stick.



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VI. MODEL 350 POWER UNIT Hydraulics

VI-1. Hydraulic Circuitry.

The following are descriptions of the components that make up the Hydraulic Circuitry of the APE Model 350 Power Unit.

VI-1A. Clamp Circuit. (Used for extending and retracting jaw cylinder)

Oil for the clamp circuit is provided by the clamp pump. Clamp oil is then directed from the pump to the clamp directional control valve. When the clamps witch is in the "off" position, the oil flows thought the clamp directional control valve and back to the oil tank.

When clamps witch is moved to open, solenoid "B" on the clamp directional control valve is energized the oil will flow out to the clamp cylinder and retract or open the jaws. The clamp open pressure can be seen on the clamp open pressure gage. When the clamp switch is moved to the closed position, solenoid "A" will be energized and oil flow will be directed to the clamp cylinder. The clamp cylinder will then extend or close the jaws. Clamp close pressure can be seen on the clamp close pressure gauge. When clamp comes up to pressure 4,800 psi, solenoid "A" will be de-energized, directing oil flow back to oil tank. Clamp pressure is maintained in clamp cylinder by a pilot operated check valve. At any time should the clamp pressure fall below 4,500 psi. the clamp pressure switch will re-energize solenoid "A" on the clamp control valve and direct pump flow to the clamp cylinder. Maximum clamp pressure is limited by the clamp pressure relief valve set at 4,800 psi. The quick disconnect couplers permit decoupling of clamp hoses.

VI-1B. Drive Circuit. (Used for operating APE vibrator, APE drill or any other unit)

There are two pumps (one dual pump and one half of another pump) that direct oil to the drive circuit (Vibro Motors). The maximum drive pressure is controlled by the drive pressure relief valve to 4,500 psi. When the drive switch is moved to the FWD position, solenoid "A" of the drive directional control valve is energized. Oil flow is directed to the vibro motors to rotate the eccentrics. When the drive switch is moved to the OFF position, oil flow is directed back to the tank through the drive directional control valve and solenoid "A" is de-energized.

The quick-disconnect couplings permit de-coupling of the drive and case drain hoses.



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VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

VI-1C. Return Filter.

Returning fluid is filtered by the return filters.

VI-1D. Oil Cooler.

The oil cooler cools the hydraulic fluid continuously pumped thru cooler while the engine is running. This cooler is protected by a check valve the will bypass oil back to the hydraulic tank.

VI-1E. Manual Pump.

A manual pump is provided to fill the hydraulic reservoir. A check valve prevents loss of fluid from the reservoir back through the manual pump.

VI-1F. Hydraulic Oil Temperature.

A temperature gauge indicates hydraulic oil temperature. The sending unit is mounted on the main tank.



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VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

VI-2. Clamp Drill Manifold Assembly p/n 523003B

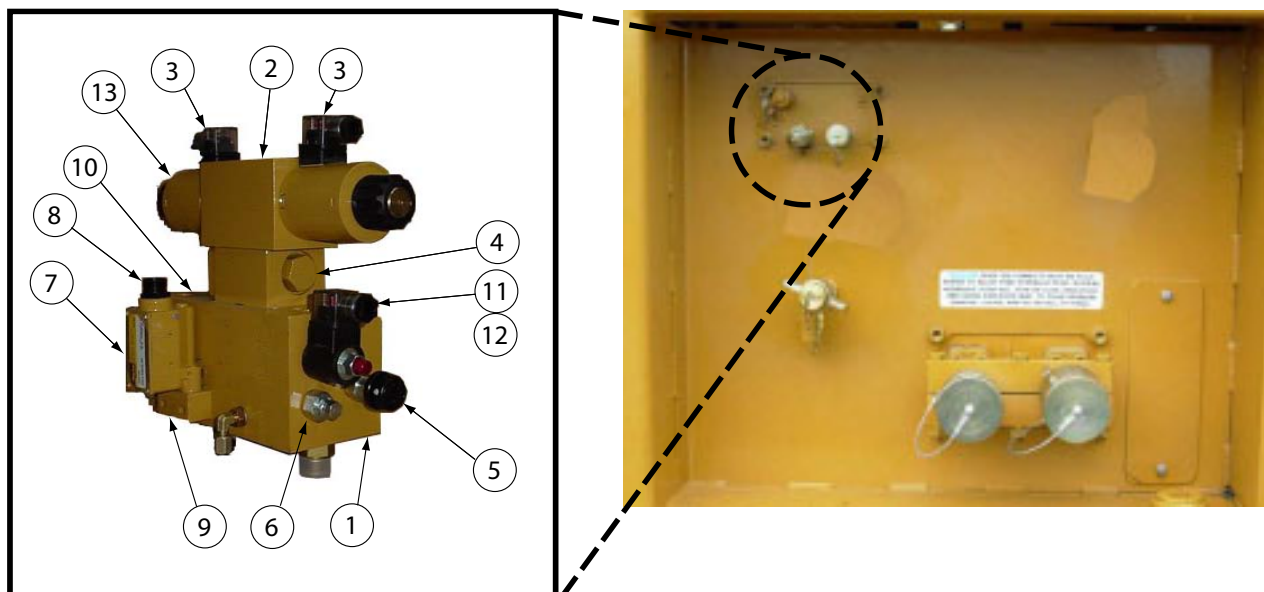


Figure 6-B. Clamp Drill Manifold Assembly

<u>ITEM</u>	<u>APE PART NO.</u>
1. MANIFOLD MACHINED	555073
2. CONTROL VALVE	555075
3. LIGHT CONNECTOR	555077
4. CHECK VALVE	555079
5. CLAMP RELIEF VALVE	555081
6. DRILL RELIEF VALVE	555083
7. PRESSURE SWITCH	555085
8. STR SO COR CONNECTOR	555087
9. 90 DEG. TURN BLOCK	555089
10. PRIORITY FLOW CONTROL	555091
11. DRILL SOLENOID VALVE	555093
12. DRILL COIL	555095
13. CONTROL VALVE COIL	555101

Table 6-A. Clamp - Drill Manifold Assembly

VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

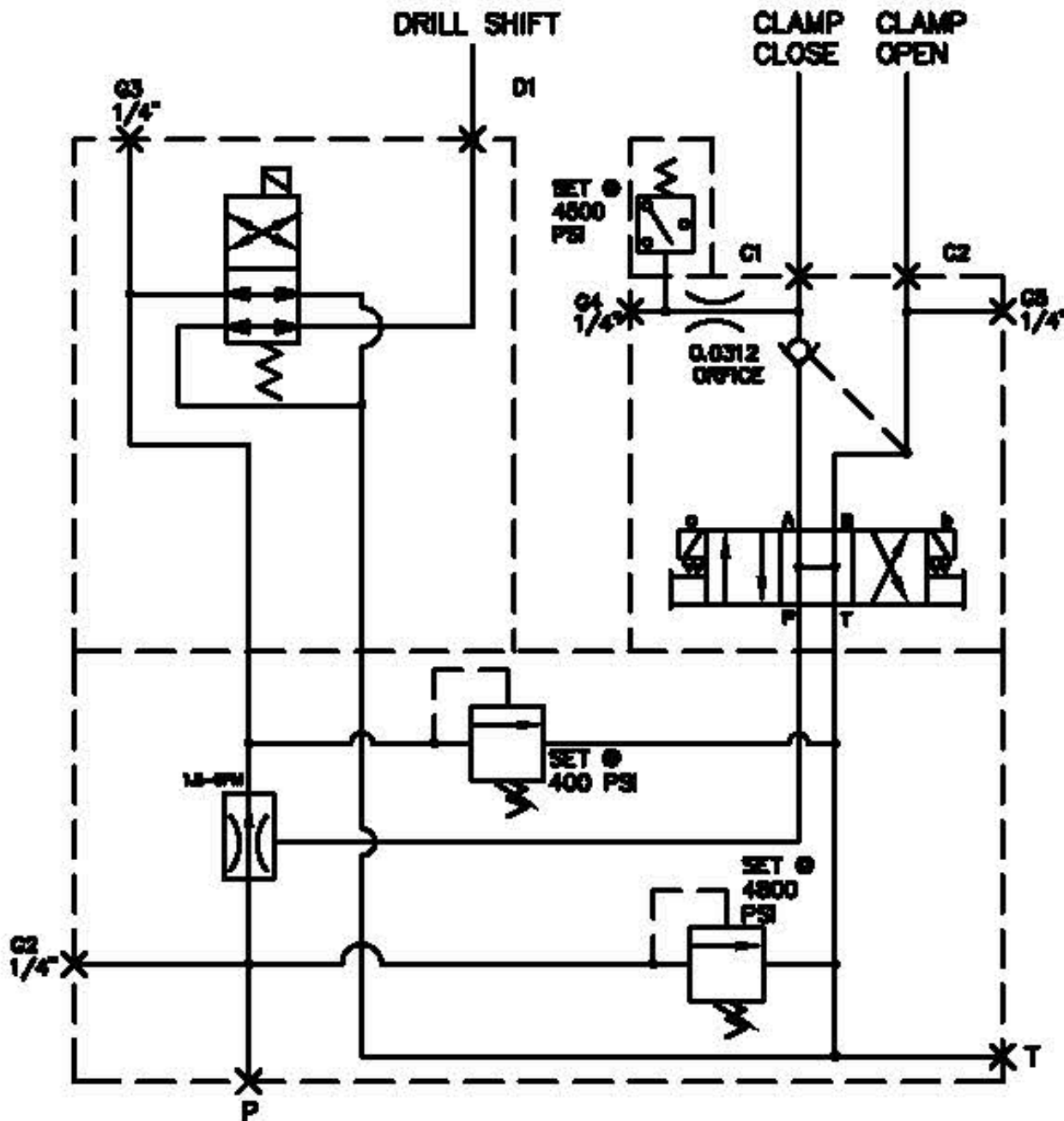


Figure 6-C. Hydraulic Schematic - Clamp Drill Manifold

VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

VI-3. Drive Manifold Assembly p/n 513028A

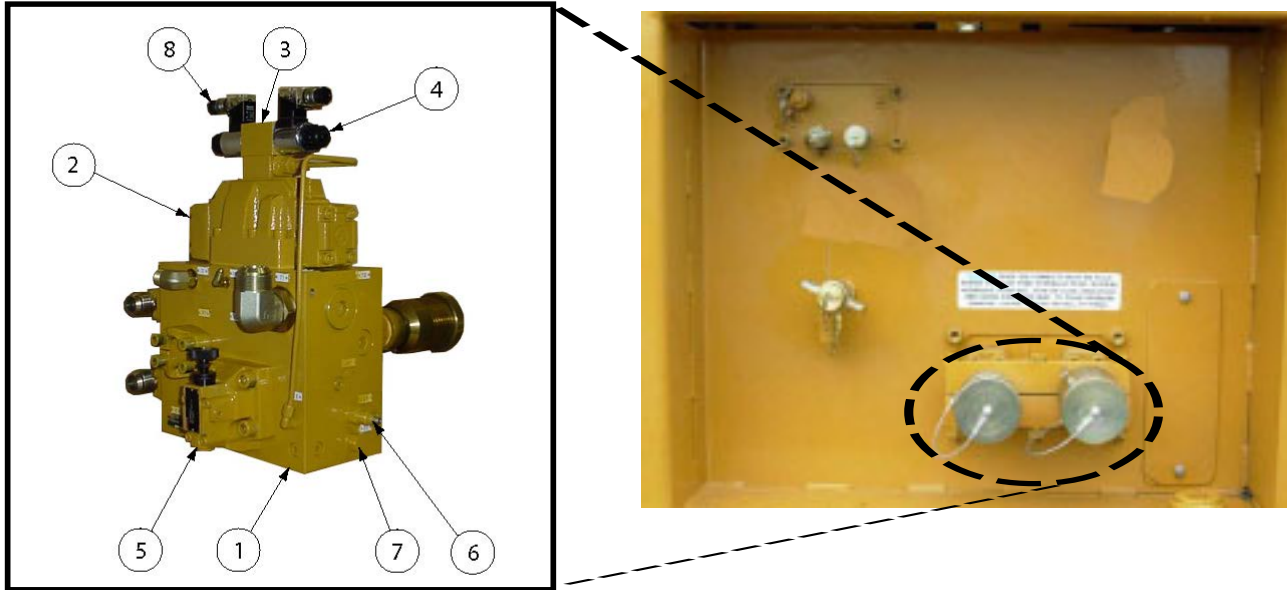


Figure 6-D. Drive Manifold Assembly

<u>ITEM</u>	<u>APE PART NO.</u>
1. MANIFOLD MACHINED	555065
2. MAIN CONTROL VALVE	555067
3. SOL CONTROL VALVE	543041
4. COIL	543043
5. RELIEF VALVE	513018B
6. NEEDLE VALVE	555069
7. CHECK VALVE	555071
8. LIGHTED CONNECTOR	513048

Table 6-B. Drive Manifold Assembly

VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

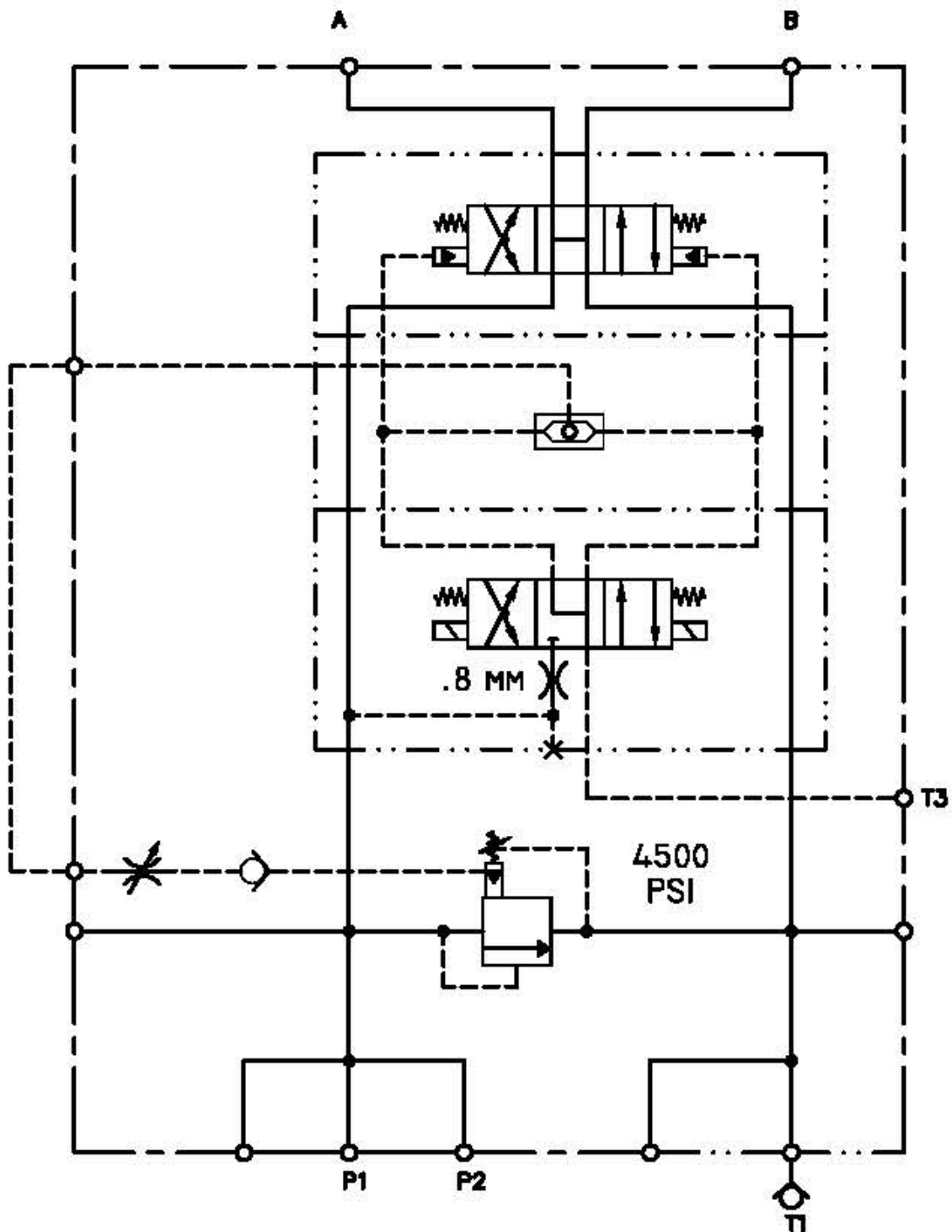


Figure 6-E. Hydraulic Schematic - Drive Manifold

VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

VI-4. Hydraulic Tank Detail

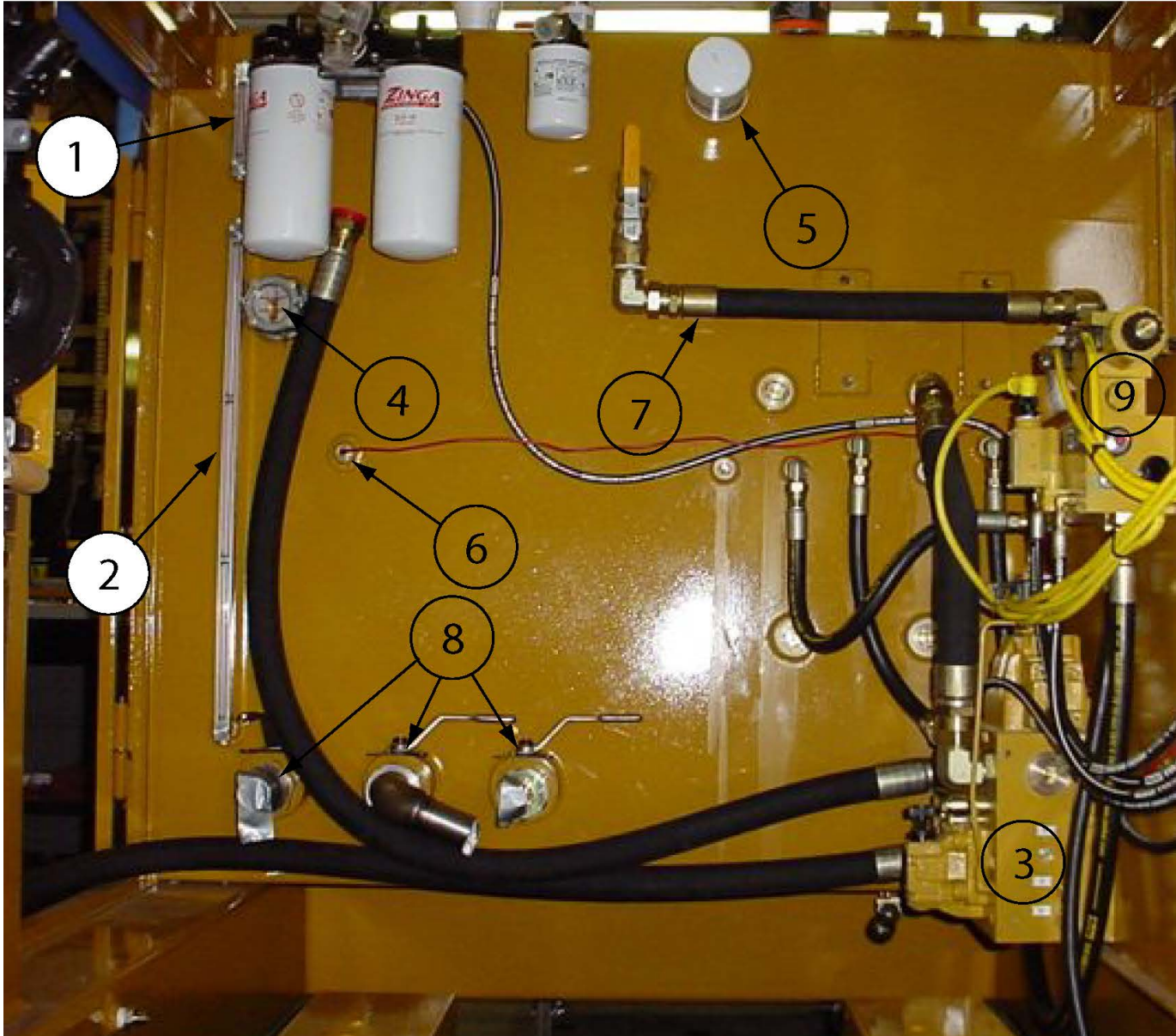


Figure 6-F. Hydraulic Tank Detail



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VI. MODEL 350 POWER UNIT Hydraulics (Continued...)

<u>ITEM</u>	<u>APE PART NO.</u>
1. 6" Sight Gauge	513003
2. 30" Sight Gauge	513005
3. Drive Manifold Assy.	513028
4. Level Switch	513033
5. Air Breather	555141
6. Temp Switch	523016
7. Hyd Tank Tranfer Assy.	
8. Suction Valve (to pumps)	555001
9. Clamp-Drill Manifold Assy.	523003B

Table 6-C. Hydraulic Tank Detail



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MODEL 150/150T VIBRATORY DRIVER WITH MODEL 350 POWER UNIT

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VII. MODEL 350 POWER UNIT ELECTRICAL

VII-1. Electrical Controls: (Understanding How They Work)

The Main Control Panel (located behind one of the doors on the side of the Power Unit) contains all of the equipment necessary to Start, Control, and Monitor the Engine, as well as control the Vibro functions. Remote control of the Vibro functions can be achieved by plugging a Pendant into the 12 pin receptacle, located on the bottom of the panel. The Pendant will allow the operator to move about in approx. a 50 ft radius of the Power Unit.

VII-1A. Main Circuit Breaker

A circuit breaker is provided to protect the control wiring in the event of an electrical overload or a shorted circuit. If the circuit breaker should trip, find and repair the fault, then reset the breaker by pressing the circuit breaker reset button on the face of the Control Panel.

VII-1B. Tachometer

A digital tachometer, located on the front of the control panel, is provided to monitor the engine RPM. A magnetic sensor picks up a signal from the flywheel, and sends it to the tachometer. If there is reason to doubt the accuracy of the tachometer, check the engine RPM with a phototach, then calibrate the tachometer gage. The factory should be consulted for proper setting of the tach switches.

VII-1C. Hourmeters

Two hourmeters are on the Control Panel, one on the face of the panel, and one inside the panel. The hourmeter on the face of the panel monitors the time that the engine is running. The hourmeter inside the panel monitors the time that the "Forward Drive" is operating.

VII-1D. Engine Safety Shutdown Switch (Murphy Magnetic Switch)

Mounted to the back side of the Control Panel Door, is a Murphy Magnetic switch with a manual reset button protruding through the front of the Panel Door "ENGINE FAULT". When the contact on the switch is closed, power is supplied to the fuel valve solenoid, the hourmeter, and the "System OK" light. When the contact is open, the above items will be de-energized, and the engine will not run. The contact can be manually closed by pressing the "ENGINE FAULT" button on the face of the control panel. The contact will remain latched closed, unless the coil on the switch is energized. Each time the coil is energized, the contact will be unlatched, and the contact will open, to stop the engine. There are five switches that can energize the coil on the Murphy magnetic Switch, to stop the engine, (Engine Oil Pressure Gage, Engine Coolant Temperature Gage, Hydraulic Oil Temperature Gage, Hydraulic Oil Level Switch, and Emergency Stop Button on either the Pendant Switch, or the Radio).

VII-1E. Murphy "Engine Oil Press" gauge

The Engine Oil Pressure Gage is located on the door of the Main Control Panel. A low cutoff switch is located inside the Murphy "Engine Oil Press" gauge. When the engine oil pressure is too low, the switch will close to energize the coil in the Murphy Mag Switch. The cutoff pressure has been set at the factory. If the setting should need to be changed, use the adjustment screw provided in the front of the gage. A 1/16" allen wrench is required. Each time the engine is to be started, the Murphy Mag Switch coil will be energized by the switch in this gage. To start the engine, one must press and hold the manual reset button on the Murphy Mag Switch until sufficient engine oil pressure is achieved. Sufficient oil pressure has been achieved when the "Oil Press" light on the face of the Control Panel goes out.)



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VII. MODEL 350 POWER UNIT ELECTRICAL (Continued...)

VII-1F. Murphy “Engine Coolant Temp” gauge

The Engine Coolant Temperature Gauge is located on the door of the Main Control Panel. A high cutoff switch is located in the Murphy “Engine Coolant Temp” gauge. When the engine temperature is too high, the switch will close to energize the coil in the Murphy Mag Switch. The cutoff pressure has been set at the factory. If the setting should need to be changed, use the adjustment screw provided in the front of the gage. A 1/16” allen wrench is required. (Do not set the cutoff temperature above 220 deg F.

VII-1G. Murphy “Hyd Oil Temp” gauge

The Hydraulic Oil Temperature Gauge is located in the Gauge Assembly on the left of the Control Panel. A high cutoff switch is located in the Murphy “Hyd Oil Temp” gauge. When the hydraulic oil temperature is too high, the switch will close to energize the coil in the Murphy Mag Switch. The cutoff temperature has been set at the factory. If the setting should need to be changed, use the adjustment screw provided in the front of the gage. A 1/16” allen wrench is required.

VII-1H. Hydraulic Oil Level Float Switch

The “Hyd Oil Level” float switch is located in the hydraulic oil reservoir, next to the sight gage. A glass window is provided in the switch so that the float and oil level can be observed. If the oil level gets too low, the switch will close to energize the coil in the Murphy Mag Switch.

VII-1I. “Emergency Stop” button

To stop the engine in an emergency, press the “Emergency Stop” button on the Pendant. This “Emergency Stop” switch will work, regardless of the position of the “Local-Pendant” Switch.

VII-1J. Pilot lights

There are five pilot lights on the face of the control panel that are associated with the Safety Shutdown Switch discussed above.

1. “System OK” light. A lit “System OK” light is an indication that the Engine Oil Pressure, Engine Coolant Temperature, Hydraulic Oil Temperature, and the Hydraulic Oil Level are all okay. When the “System OK” light is not lit, the engine will have been automatically stopped. The problem can be detected by observing the following lights.

2. “Engine Oil Press” light. Any time the engine oil pressure is too low, this light will be on, (with the following exception). If the “Engine Coolant Temperature Gauge”, the Hydraulic Oil Temperature Gage, or the Hydraulic Oil Level Switch has stopped the engine, the “Engine Oil Press” light will not be on; but, one of the following lights will be on.

3. “Engine Coolant Temp” light. If the Engine Coolant Temp is too high, this light will be on.

4. “Hydraulic Oil Temp” light. If the Hydraulic Oil Temperature is too high, this light will be on.

5. “Hydraulic Oil Level” light. Any time the Hydraulic Oil Level is too low, this light will be on.

In addition to the above, there is a pilot light in each of the terminal connectors on the solenoid valves. By observing these lights, one can tell which solenoids are energized.



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VII. MODEL 350 POWER UNIT ELECTRICAL (Continued...)

VII-1K. Engine Control Switch “OFF-ON-START”

The Engine Control Switch is located on the front of the control panel, and is used to start and stop the diesel engine, as well as control power to all other electrical equipment on the power unit. This switch must be in the “on” position before the engine or any of the other electrical components will operate. The “off” and “on” positions are detented, but the “start” position is spring loaded to the “on” position. Turning the switch to the “start” position will energize the starter motor on the engine.

VII-1L. “LOCAL— PENDANT” Switch

This switch is also located on the main control panel, and determines the location from which the vibro can be operated. The vibro can not be operated from more than one location at a time. When this switch is turned to the “local” position, the vibro can be operated only by the switches on the power unit control panel. In the “pendant” position, operation of the vibro is controlled by the Hand Held Pendant plugged into the bottom of the Control Panel.

CAUTION should be used when changing the position of this switch. Check to make sure that all of the Drive “Forward/Reverse” switches, and “Clamp” switches are turned “off” before turning this switch. If any one of the above switches are “on”, the vibro eccentrics or clamp could be accidentally activated, causing mechanical damage or personal injury.

If the Hand Held Pendant is plugged into the Receptacle on the bottom of the Control Panel, this switch must be in the “local” position before the engine can be started.

VII-1M. Governor Control Switches “RAISE-off-LOWER”

Governor Control switches can be found on the Main Control Panel and the Hand Held Pendant. The “Local-Pendant” switch determines which one is operable. To increase the engine rpm, turn the appropriate governor control switch to the “Raise” position. To decrease the engine rpm, turn the switch to the “Lower” position. The “Local-Pendant” switch determines which one is operable.



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VII. MODEL 350 POWER UNIT ELECTRICAL (Continued...)

VII-1N. Clamp Control Switches (“OPEN-off-CLOSE”)

A Clamp Control Switch can be found on the Main Control Panel and the Pendant. The “Local-Pendant” switch determines which one is operable.

The Clamp Control Switches on the Control Panel and the Pendant are detented in the “off” and “close” positions. The “open” position is spring loaded back to the “off” position.

When the ‘active’ Clamp Control Switch is in the “off” position, oil from the Clamp Pump is routed through the Clamp Solenoid Valve back to tank.

When the Clamp Control Switch is turned to the “open” position, The “open” solenoid on the Clamp Valve is energized, causing oil to be directed to the rod end of the Clamp Cylinder, provided the drive “Forward/Reverse” Switch is in the “off” position. (The clamp “open” solenoid cannot be energized when the “Drive Forward” switch is activated. If the Clamp Control Switch is held in the “open” position after the clamp is fully open, oil pressure will build in the system until oil is flowing over a pressure relief valve, creating heat.

When the Clamp Control Switch is turned to the detented “Close” position, the “close” solenoid on the Clamp valve is energized, causing oil to be directed to the blind end of the Clamp Cylinder. Once the Clamp is closed, and sufficient oil pressure (4,500psi) has built in the system, a pressure switch will open the circuit to the solenoid valve, and energize a pilot light located in the Clamp Control Switch. A lit pilot light in the Clamp Control Switch is an indication that there is enough oil pressure in the clamp circuit to safely run the vibro.

If oil pressure in the Clamp circuit should bleed off to a predetermined level(4,000psi), the pressure switch will de-energize the pilot light, and re-energize the “close” solenoid on the Clamp valve until pressure in the clamp circuit reaches 4,500psi again. This cycle will continue until the Clamp switch is turned to the “off “ position.



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VII. MODEL 350 POWER UNIT ELECTRICAL (Continued...)

VII-10. Drive Control Switches (“FORWARD/off/REVERSE”)

Drive Control Switches can be found on the Main Control Panel and the Pendant. The “Local-Pendant” Selector Switch determines which one is operable.

The Drive Control Switches on the Control Panel and the Pendant are detented in all three positions. They must be in the “off” position, before the engine can be started.

When operating a Drill, both the “Forward” and “Reverse” positions can be used. The “Forward” position would be used to drive the drill forward (Clockwise rotation). The “Reverse” position would be used to drive the drill backwards (Counter clockwise rotation).

When operating the eccentrics on a vibro, only the “Forward” drive should be used. If the “Reverse” drive is used, the majority of the oil will pass through the anti-cavitation valves located in the vibro suppressor housing, and the vibro eccentrics will not run properly.

When a drive is turned “on”, it should always be turned “off”, and the equipment allowed to stop, before the opposite drive is turned “on”.

VII-1P. Preparing the Electrical System for Engine Startup.

The following procedure should be followed at Engine Startup:

- 1.The Circuit Breaker must be closed (Pushed in and locked).
- 2.Turn the Clamp Switches on both the Control Panel and the Pendant to the ‘Off’ position.
- 3.Turn the Drive Switch on both the control panel and the Pendant to the ‘Off’ position.
- 4.If the Pendant is plugged into the receptacle on the bottom of the Control Panel, the Local/Pendant switch must be in the ‘Local’ position.
- 5.Turn the Engine Control Switch to the ‘On’ position.
- 6.Check the Pilot Lights on the face of the Control Panel. If any of the lights, other than the “Engine Oil Pressure’ light is on, correct the problem before proceeding. If the ‘Engine Oil Pressure’ light is on, proceed.
- 7.Depress and hold the button on the Engine Fault Switch (Murphy Switch. This button must be depressed until Engine Oil Pressure is present.
- 8.Turn the Engine Control Switch to the ‘Start’ Position to engage the Starter Motor and release upon starting.
- 9.Once Engine Oil Pressure is present, release the Engine Fault Switch.



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VII. MODEL 350 POWER UNIT ELECTRICAL (Continued...)

VII-2. Pendant

A remote hand held "PENDANT" is provided to allow operation of the power unit at a distance of up to 50 feet (15 meters) and can be extended using 50 foot extension cables. The "PENDANT" is connected to the control panel via a multi-connector plug.

The Pendant is particularly handy as a trouble shooting tool, in that the operator can position himself near the Control Valves while checking them. To make the Pendant operable, turn the 'Local-Pendant' Switch to the 'Pendant' position, and the Engine Control Switch to the 'On' Position. (The Engine does not need to be running. Each time a solenoid is energized, a pilot light on the connector to that solenoid should light up.

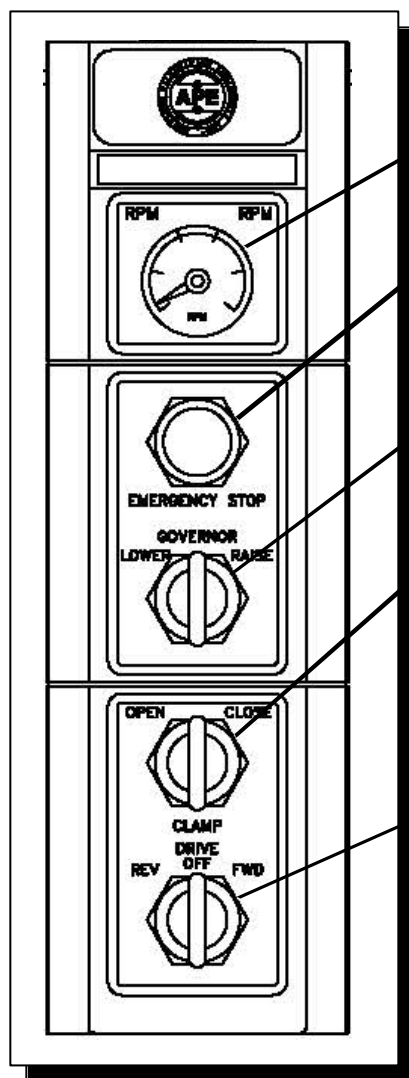


Figure 7-L. Pendant

TACHOMETER

Indicates Engine RPM

ENGINE EMERGENCY SHUTDOWN SWITCH

Press and hold to shut engine off. Do not use to shut engine off at the end of shift. Shut unit off at panel at end of shift. Button is for emergency only.

ENGINE THROTTLE "RAISE/LOWER" RPM

Three Position Switch. Turn and hold switch to raise or lower deisel engine rpm.

CLAMP OPEN/CLAMP CLOSE

Lighted switch. Move to close to extend jaw and clamp vibro to pile. Light comes on when clamp is closed and locked. Turn to open to retract jaw and release vibro from pile. Switch must remain in closed position to hold clamp to pile. Sometimes the light will not come on. It could be burnt out or shorted. Check clamp pressure gauge and make sure it reads at least 4,000 psi before vibrating any pile.

FORWARD/OFF/REVERSE

Three position switch. Turn to forward to operate vibro. Turn to off to stop vibro. Turn to reverse when using power unit to run a drill motor. Vibro is not supposed to vibrate in reverse. If it does then switch the two yellow cables labled "drive" and "reverse" located on the other side of the control panel.

WARNING: Never leave vibro clamped to a pile without the crane line attached. The clamp cylinder could bleed off causing the vibro to drop. Never hoist a pile in the air without a safety line attached to the pile. Should the clamp close line become damaged and leak, the clamp cylinder could lose pressure and drop the pile.



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VII-3. Recommended Bolt Tightening Torque

Nominal Screw Size	Nominal Socket Size	Tightening Torque Ft-Lbs. (Kg-M)	Nominal Screw Size	Nominal Socket Size	Tightening Torque Ft-Lbs. (Kg-M)
#10-24	5/32	6 Ft-Lbs. (.83 Kg-M)	#10-32	5/32	6 Ft-Lbs. (.83 Kg-M)
1/4-20	3/16	13 Ft-Lbs. (1.8 Kg-M)	1/4-28	3/16	15 Ft-Lbs. (2.1 Kg-M)
5/16-18	1/4	27 Ft-Lbs. (3.7 Kg-M)	5/16-24	1/4	30 Ft-Lbs. (4.2 Kg-M)
3/8-16	5/16	48 Ft-Lbs. (6.6 Kg-M)	3/8-24	5/16	55 Ft-Lbs. (7.6 Kg-M)
7/16-14	3/8	77 Ft-Lbs. (10.6 Kg-M)	7/16-20	3/8	86 Ft-Lbs. (11.9 Kg-M)
1/2-13	3/8	119 Ft-Lbs. (16.4 Kg-M)	1/2-20	3/8	133 Ft-Lbs. (18.4 Kg-M)
5/8-11	1/2	234 Ft-Lbs. (32.3 Kg-M)	5/8-18	1/2	267 Ft-Lbs. (36.9 Kg-M)
3/4-10	5/8	417 Ft-Lbs. (57.6 Kg-M)	3/4-16	5/8	467 Ft-Lbs. (64.5 Kg-M)
7/8-9	3/4	676 Ft-Lbs. (93.4 Kg-M)	7/8-14	3/4	742 Ft-Lbs. (102.5 Kg-M)
1-8	3/4	1,009 Ft-Lbs. (139.4 Kg-M)	1-12	3/4	1,126 Ft-Lbs. (155.6 Kg-M)
1-1/4-7	7/8	1,600 Ft-Lbs. (221.1 Kg-M)	1-1/4-12	7/8	1,800 Ft-Lbs. (248.8 Kg-M)
1-1/2-6	1	2,800 Ft-Lbs. (387 Kg-M)	1-1/2-12	1	3,000 Ft-Lbs. (414.6 Kg-M)

Table 7-F. Recommended Bolt Tightening Torque

NOTE: These values are for Socket head cap screws only. Button heads, Flat heads and Set screws have different values. Check the Allen Hand Book for correct torque specifications.



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