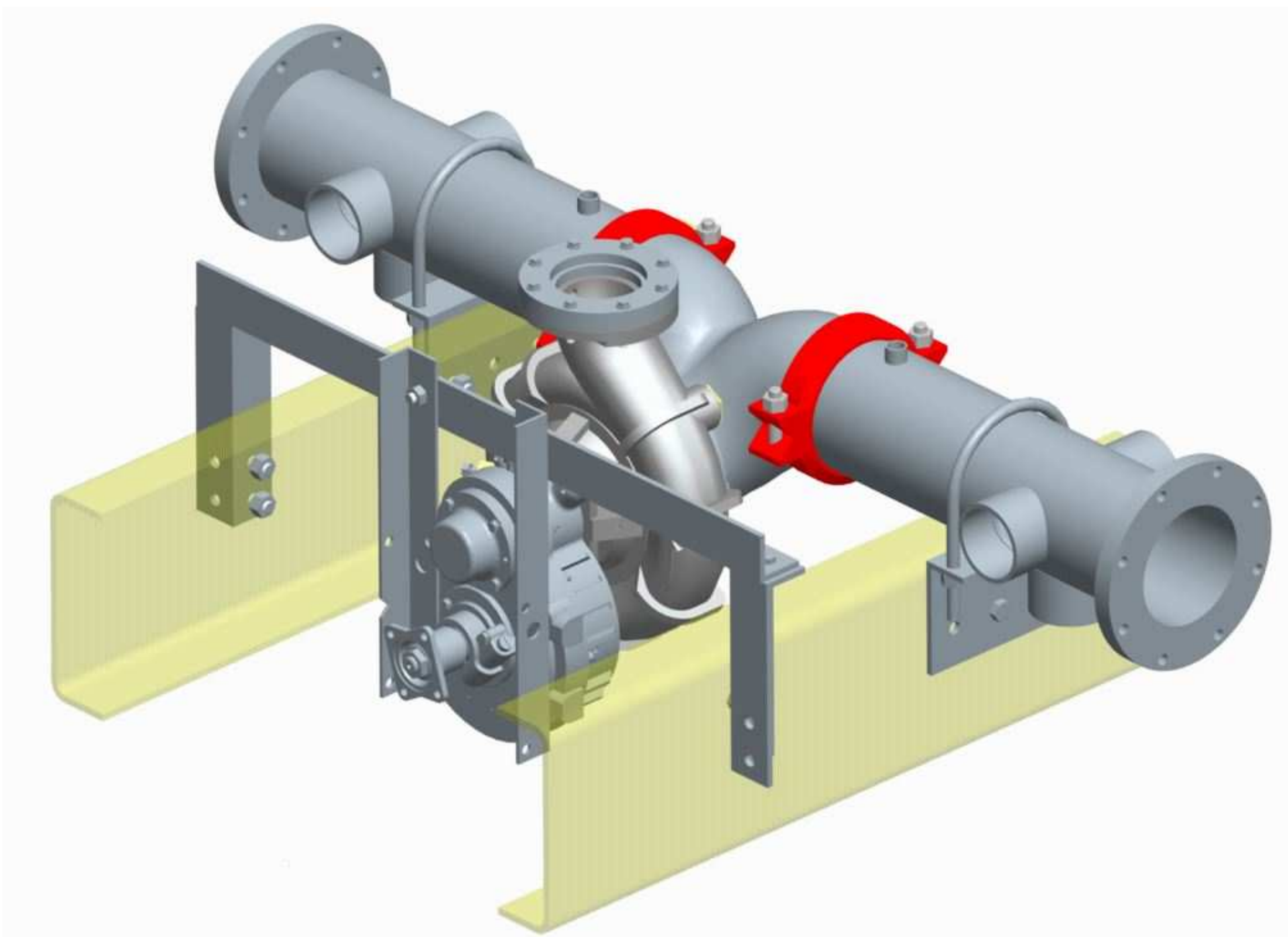
INSTALLATION OF TYPE AG, HM, JMP, KSP, LSP, PSP, & OTHER PTO DRIVEN PUMPS



Prepared by: EAS
Approved by: TED
Revised by: CWY

Rev. A
Date: 03/16/12
Rev. Date: 06/20/13
1201009.doc

Important

⚠WARNING

Rotating shafts can be dangerous. Clothes, skin, hair, hands, etc. can become snagged or tangled, causing serious injury or death. DO NOT work on a drive shaft or pump when the engine is running and without the wheels chocked.

⚠WARNING

Great care must be taken in the layout of pump systems drivelines. Interference and driveline vibration must be considered. A sufficiently experienced installer with knowledge of driveline considerations, proper layout and recommended guidelines should be utilized as well as a proper CAD system for technically precise layouts. Installation of said drivelines should not occur until a proper analysis is performed by either said drafter or W.S. Darley. Darley utilizes and can distribute the Allison Driveline Analysis program which they use for said analysis, along with an instruction for use.

Failure to do said layout and analysis could result in severe injury and damage to equipment, including items not furnished by Darley, including but not limited to: drive tubes, hanger bearings, u-joint crosses, gears, rear differentials, and main truck transmissions.

⚠WARNING 

Exposed rotating drive-shafts should be guarded.

It is highly recommended by Darley to use safety rings around drive tubes. Especially near connecting u-joint crosses. Such safety rings would be sufficiently attached to the chassis frame and sufficiently strong enough to prevent a broken u-joint assembly from allowing a driveline to slide out from underneath the truck at high speeds while still rotating, causing severe personnel injury. Said safety rings would be larger than the drive tube OD and provide enough clearance for dynamic non-rotational movement of the drivelines through loaded and unloaded conditions, driving operations and where chassis flex may occur.

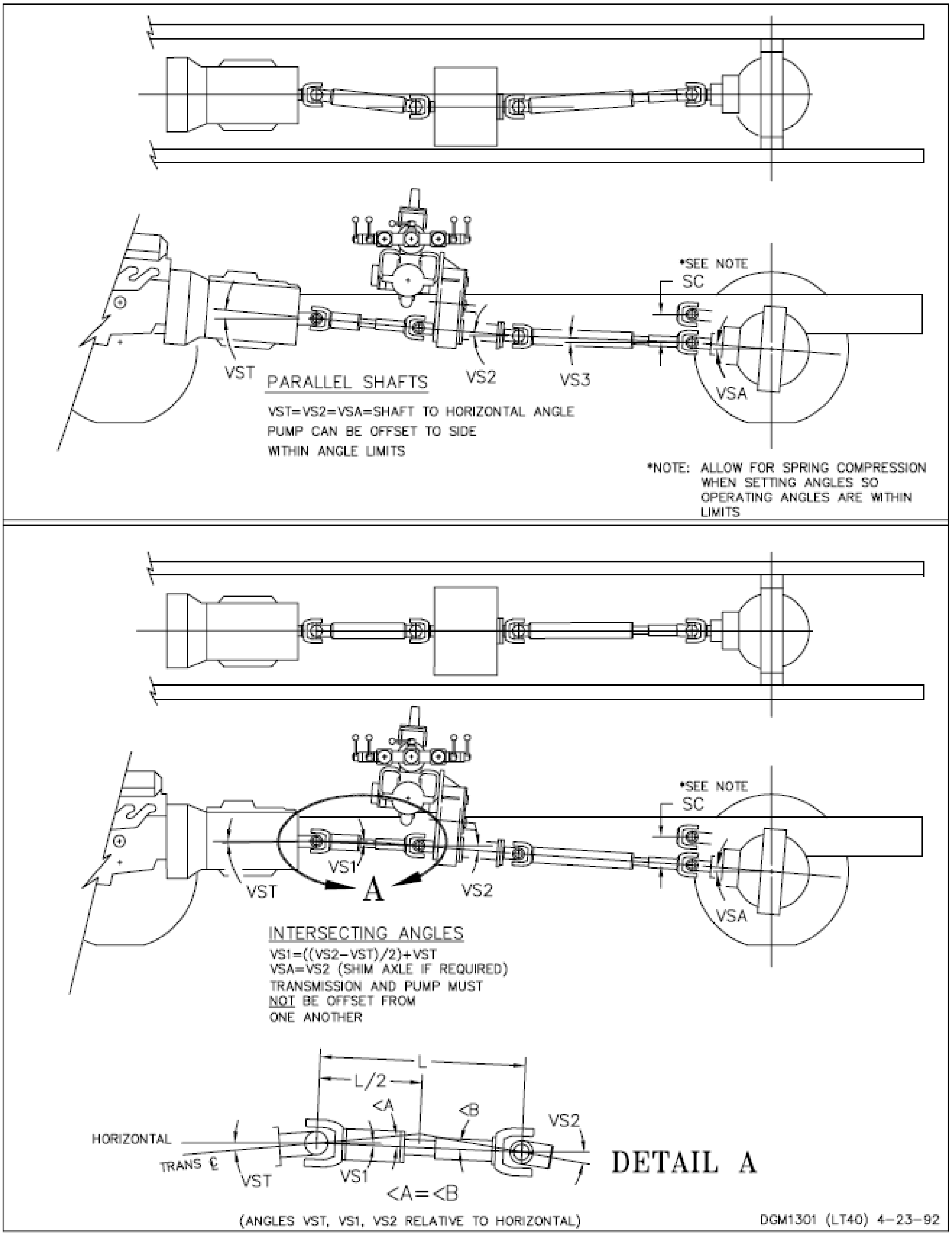
Universal Joints:

- Universal joints must always be installed in pairs to transmit uniform rotary motion.
- The operating angles of each universal joint in the pair should be as close to equal as possible.
- The input and output shafts of each universal joint pair may be either parallel, or so located that the centerline of each shaft intersects the midpoint of the shaft connecting each universal joint (intersecting angles).
    - o This arrangement may be required if the coupling shaft between pump and PTO is relatively short, or the engine is mounted with its driveshaft horizontal. Refer

to attached drawing DGM1301 for examples of parallel shaft and intersecting angle installations.

- o DGM1301 shows a midship split shaft style pump, but the same installation recommendation/information applies to PTO's and PTO driven pumps.

See the appendix of this portion of the manual for the Spicer Driveline Installation Guide (J3311-1-DSSP)



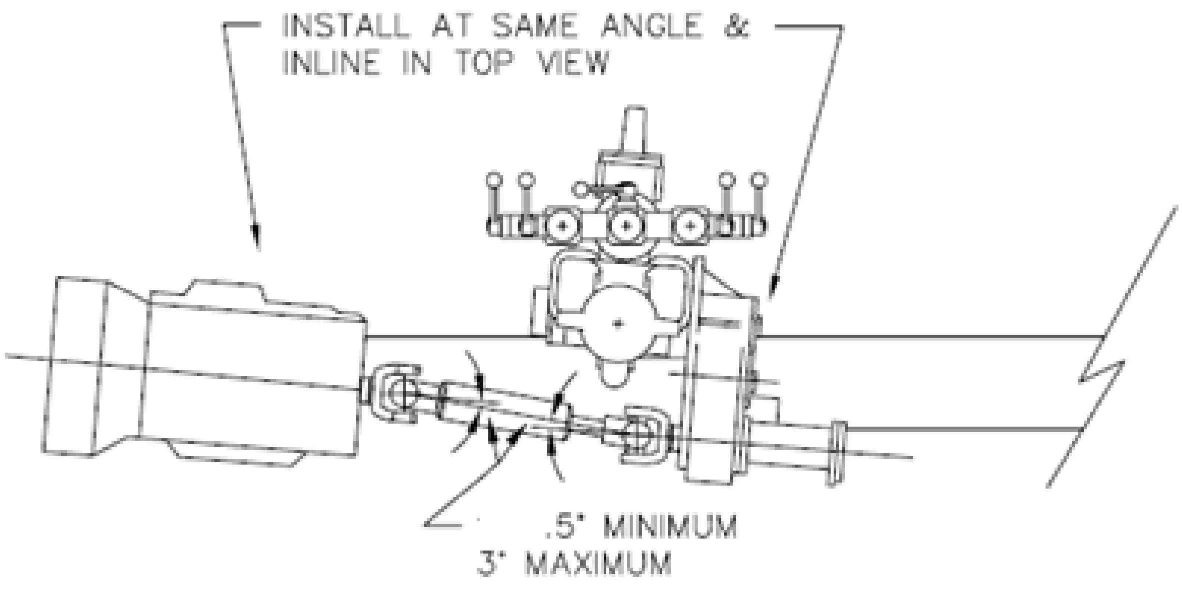
Driveline and Mounting:

- Determine the best location for the pump in your chassis. Allow adequate room for pump maintenance.
- Place the pump/cross-member assembly on the chassis frame at the desired location. Be sure to set cross-member ends on the weld brackets. (See detail drawing DSM0103.)
- Measure the vertical angle between the truck PTO shaft centerline and chassis frame (often 4^o).

- **For pumps that use <u>studs</u> to support the rear of the pump** from the pump cross member, attach the rear cross-member support to the pump using 5/8" diameter studs, nuts, and lockwashers.
  - o Tighten the stud locknuts on the pump transmission bearing cap only.
  - o Omit lockwashers on the top side of the cross-member, as nuts only will be used to position the pump.

- Place metal shims between the cross-member ends and weld brackets to provide the same angle.
  - o C-clamp the ends to the chassis frame rails temporarily.

- Suspend the pump so that the pump driveshaft centerline is as close as possible to being inline and parallel to the truck PTO shaft centerline. Example: If the truck PTO is at 4^o with horizontal, the pump driveshaft should also be set at 4^o with horizontal. This will insure that even if the PTO and pump are offset from each other, the universal joint operating angles will be equal.
- Check to confirm that the pump shaft is parallel to the PTO shaft.



- **For pumps that use <u>studs</u> to support the rear of the pump** from the pump cross member, use the top hanger stud nuts, on cross-member (without lockwashers) and shims under suction extensions to bring pump driveshaft centerline approximately in line and parallel to the truck PTO shaft. The pump shaft, and PTO shaft should now be at the same angle, relative to horizontal (often 4^o).
  - Make adjustment to shims between the cross-member, and weld brackets so top nuts bear flat against the angle iron cross member. Establish proper operating angles for the drive shaft.

- **For pumps that use <u>angle iron</u> to support the rear end of the pump** from the cross member, establish proper operating angles for the drive shaft. The pump shaft, and PTO should shaft now be at the same angle, relative to horizontal (often 4^o).
  - Make adjustment to shims between the cross-member, and weld brackets so the vertical angle iron bears flat against the angle iron cross member.
  - C-clamp the vertical angle iron to the pump cross member temporarily.

- **Before proceeding further, align the pump drive shaft so that it is parallel to the frame rails. More importantly, check to confirm that the pump shaft is parallel to the PTO shaft.**

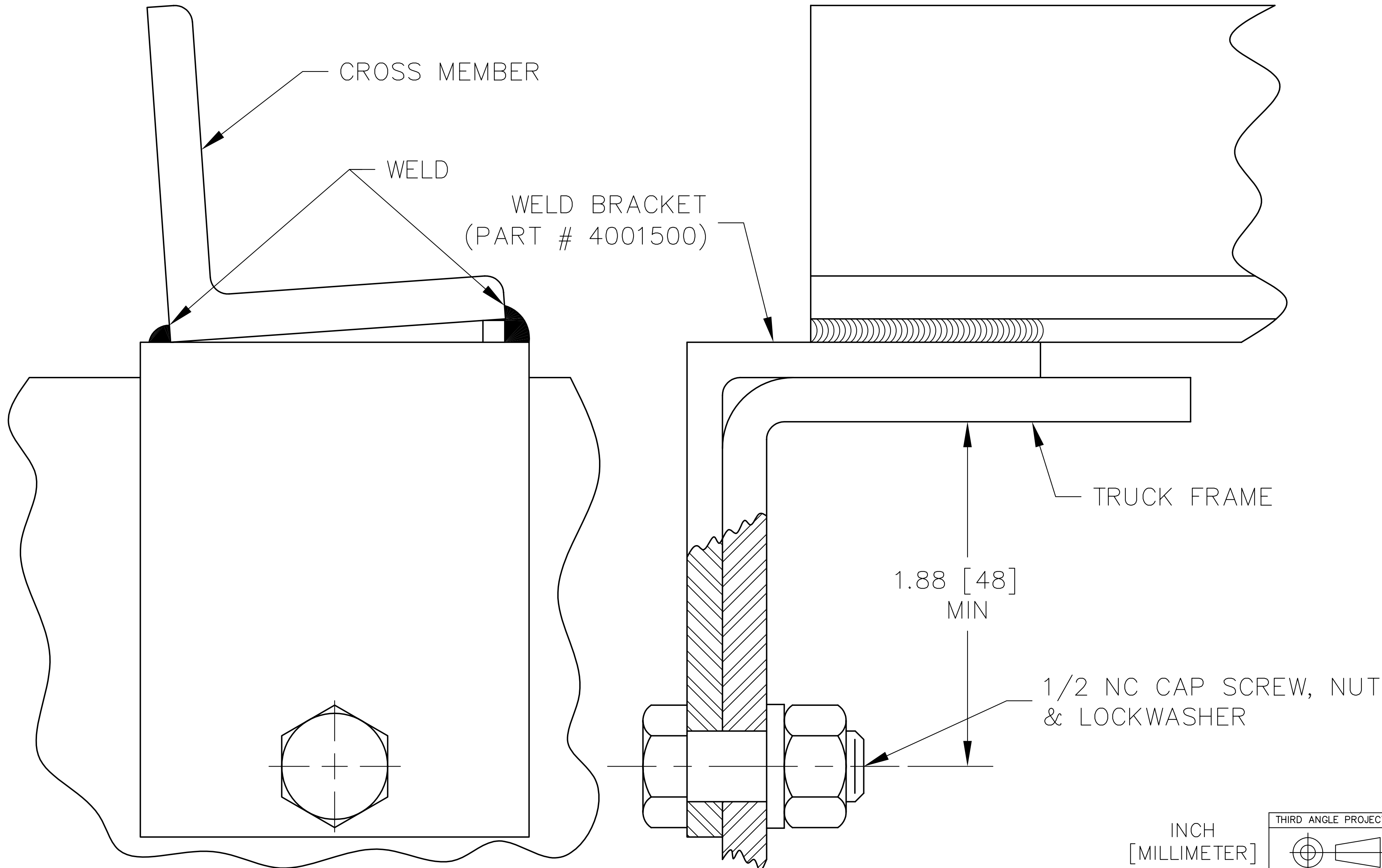
- Place mounting brackets into position as shown on detail drawing DGM1300 or DGM1302, as applicable, and securely clamp against side of frames.
  - When pipe is used for suction extension, attach brackets to the suction extensions with pipe U-bolts.
  - When mounting tabs are provided on cast suction extensions, attach the brackets to the suction extensions with 5/8” NC x 2-3/4” long cap screws. (Torque the 5/8” cap screws to 112 ft.lb.)

- Drill holes through the side frames and attach the mounting brackets.
  - Note, one mounting bracket is designed to permit truck frame flex without imposing stress on pump extensions. The bracket must be free to pivot as seen in drawing DGM1300 or DGM1302 as applicable.

- Provide adequate support for all piping.

- **Keep the following points in mind when positioning the pump and constructing the driveline.**
  - Do not exceed recommended universal joint operating angles. Complimentary shaft angles should be equal and as low as possible.
  - Do not exceed universal joint torque limitations.

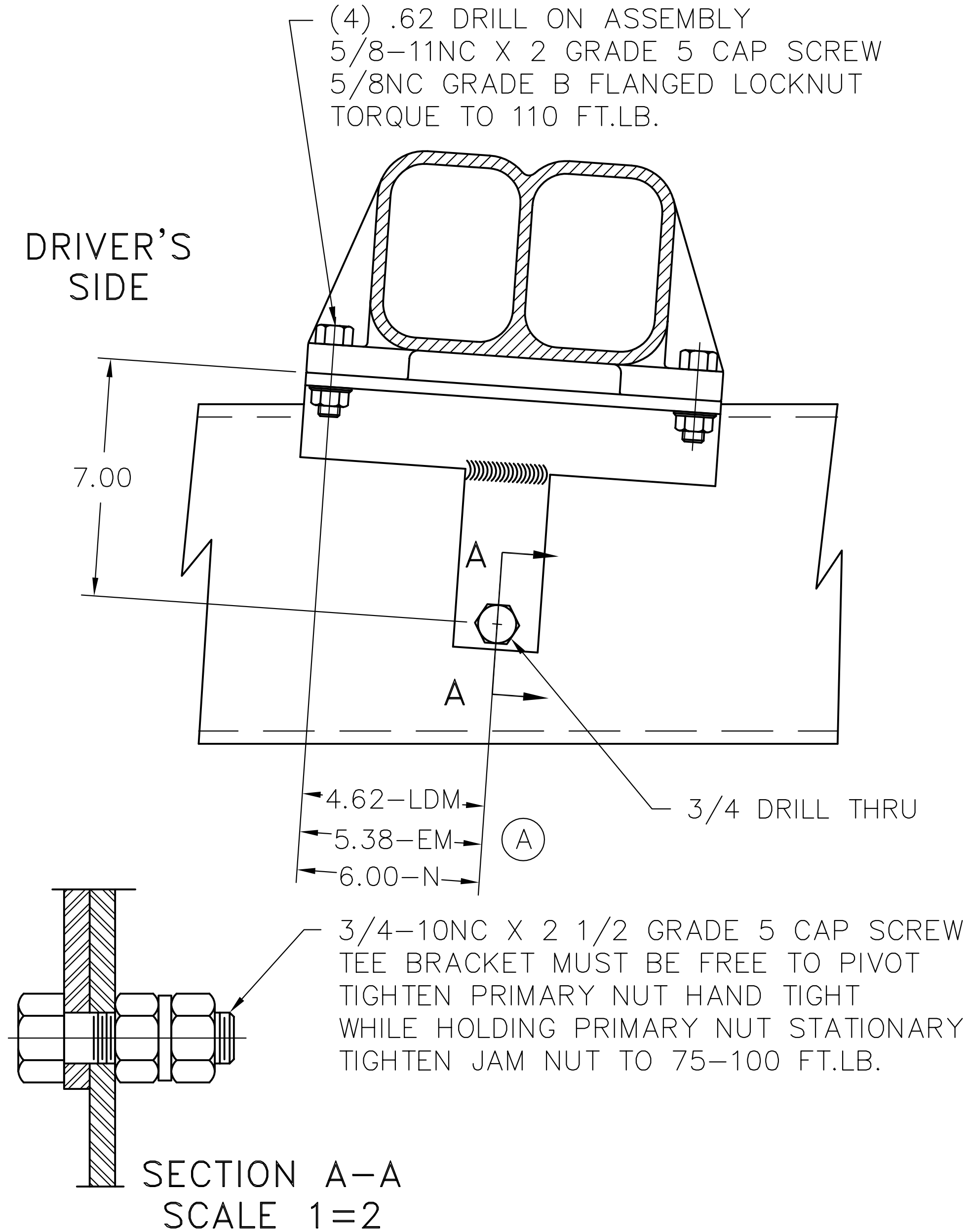
- Do not exceed driveshaft speed/length limitations.
- Yokes on each end of the drive shaft must be in phase. When in phase the yoke lugs (ears) at each end are in line.
- Use balanced driveline components to help prevent vibration and to extend the life of drive yokes and other components related to the drive line.

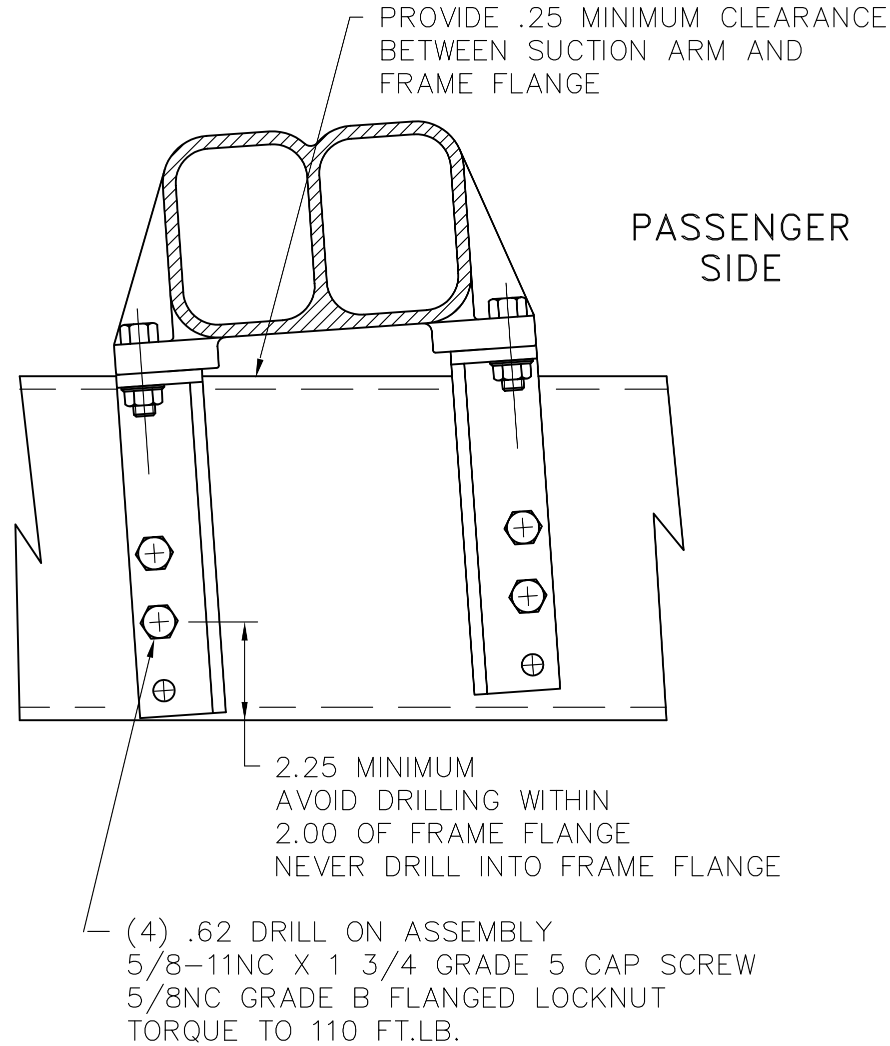


INCH
[MILLIMETER]

THIRD ANGLE PROJECTION

		OLD PART NO. S998	TOLERANCE EXCEPT AS NOTED .00 ±.03 .000 ±.010 ANGLES ±1°	W.S. DARLEY & Co. MELROSE PARK, IL – CHIPPEWA FALLS, WI
MATERIAL DESCRIPTION: —	MATERIAL NO. —	PATTERN NO. —		DWG – PUMP SUPPORT —
			DR'N JCM	DATE 9–13–77
THIS DESIGN IS THE PROPERTY OF W.S. DARLEY AND CO. – UNAUTHORIZED REPRODUCTION IS PROHIBITED	ALL DIMENSIONS IN INCHES UNLESS NOTED	DO NOT SCALE PRINT	CHKD	DSM0103
			TRCD TED11/9/98	SCALE 1/1





REV.	DATE	CHANGE
A	30SEP2003	ADDED DIMENSIONS FOR LDM, AND N PUMP

TOLERANCE EXCEPT AS NOTED
FRAC DIM ±.01
.00 ±.01
.000 ±.005
ANGLES ±1°

W.S. DARLEY & CO.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

DWG – MOUNTING BRACKET DETAIL
EM, LDM, N

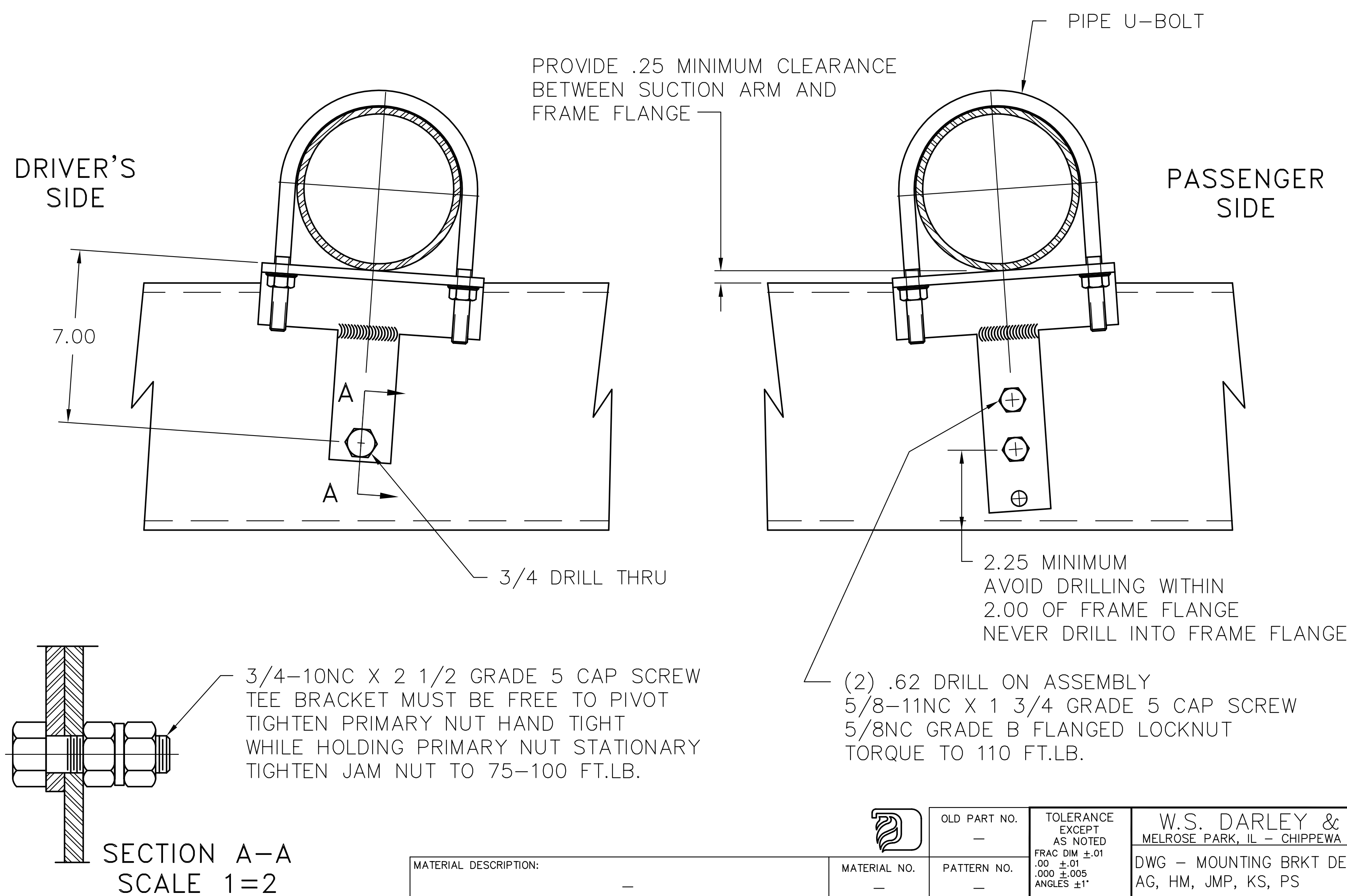
DR'N DWS
CHKD
TRCD TED

DATE OCT16,1998
SCALE 1/4

DGM1300

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT



OLD PART NO. —

TOLERANCE EXCEPT AS NOTED
FRAC DIM ±.01
.00 ±.01
.000 ±.005
ANGLES ±1°

W.S. DARLEY & CO.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

MATERIAL DESCRIPTION: —

MATERIAL NO. —

PATTERN NO. —

DWG – MOUNTING BRKT DETAIL
AG, HM, JMP, KS, PS

DR'N TED
CHKD
TRCD

DATE NOV9,1998

SCALE 1/1

DGM1302

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT

Torque the universal joint bearing cap retaining bolts to the following Dana Spicer Recommendations.

U-BOLT

SERIES		*RECOMMENDED NUT TORQUE*
1280		14-17 LB. FT
1310		14-17 LB. FT
1330		14-17 LB. FT
1350		20-24 LB. FT
1410		20-24 LB. FT
1480		32-37 LB. FT
1550		32-37 LB. FT

BEARING STRAP

SERIES		*RECOMMENDED BOLT TORQUE*
SPL90		45-60 LB. FT
1210		13-18 LB. FT
1280		13-18 LB. FT
1310		13-18 LB. FT
1330		13-18 LB. FT
1350		30-35 LB. FT
1410		30-35 LB. FT
1480		55-60 LB.FT
1550		55-60 LB.FT
1610		55-60 LB.FT
1710		130-135 LB. FT
1760		130-135 LB. FT
1810		130-135 LB. FT

CAP & BOLT

SERIES		*RECOMMENDED BOLT TORQUE*
1650		77-103 LB. FT
1850		110-147 LB. FT
1850		110-147 LB. FT
1910		110-147 LB. FT
1950		271-362 LB. FT
2010		102-118 LB. FT
2050		744- 844 LB. FT
2110		171-197 LB. FT
2150		744- 844 LB. FT
2210		260- 298 LB. FT

BEARING PLATE

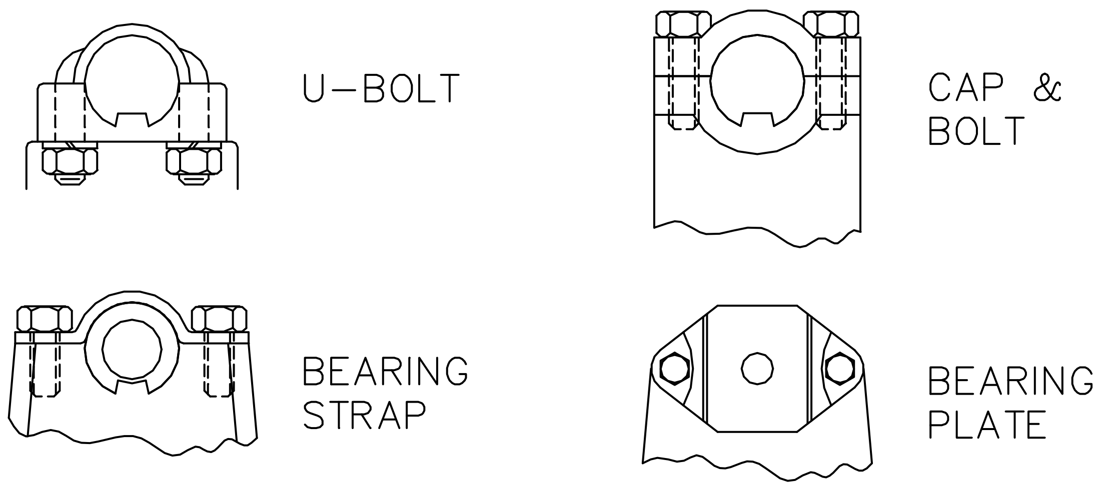
SERIES		*RECOMMENDED BOLT TORQUE*
1610		26-35 LB. FT
1710		38-48 LB. FT
1760		38-48 LB. FT
1810		38-48 LB. FT
1880		60-70 LB.FT

New part kits with lockstraps available from Spicer after Spring 1994

SERIES		*RECOMMEND BOLT TORQUE*
1610		17-24 LB. FT
1710		32-42 LB. FT
1760		32-42 LB. FT
1810		32-42 LB. FT
1880		50-66 LB. FT

WARNING: Bearing strap retaining bolts must **NOT** be reused!
WARNING: Self locking bolts must **NOT** be reused!

Note: The Dana Spicer fastener torque recommendations are per Dana Spicer's literature # 3119-5 DSD 4/94.

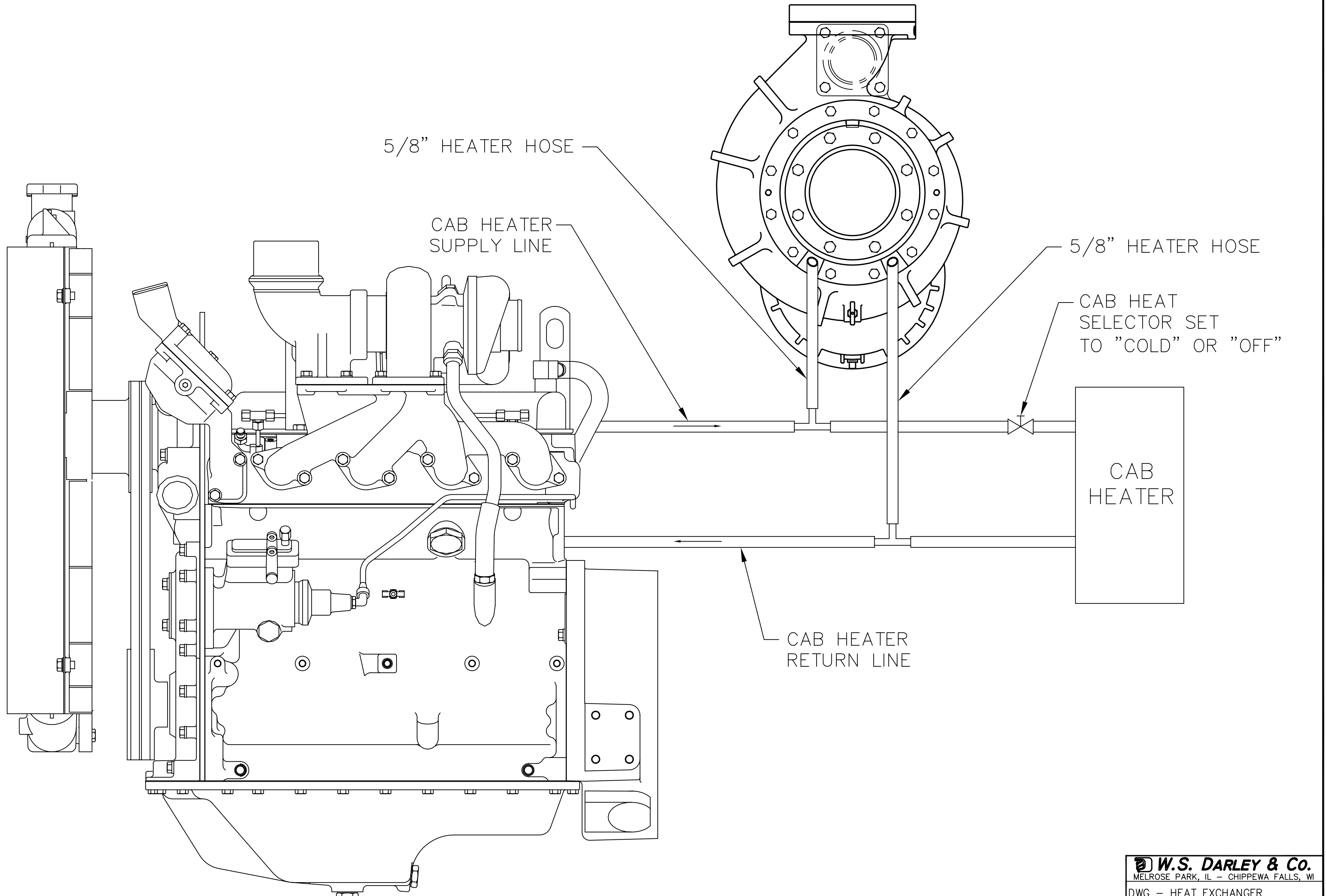


Lubricate universal joint cross using a good quality E.P. (extreme pressure) grease meeting N.L.G.I. E.P. Grade 2 specifications. (Consult your local lubricant source for greases that meet this specification.)

__PRIMER CONNECTION:__ For 12/24-volt electric motor driven priming pump installation, see drawings DVC0207 through DVC0212 found in the "Pump Detail" section of your main pump "Installation, Operation, Maintenance, Repair and Troubleshooting Manual".

__ENGINE COOLING/PUMP HEATER:__ On most pumps, two tapped openings in the pump suction head are provided for circulating engine coolant through the heater jacket/heat exchanger to prevent pump freezing in cold weather, and to aid in engine cooling in warm weather. Use no smaller than a 1/2" heater hose for this connection. See drawing DGS0400. An external heat exchanger should be added to aid in cooling the engine on units that do not have an internal heater jacket/heat exchanger in the suction head.

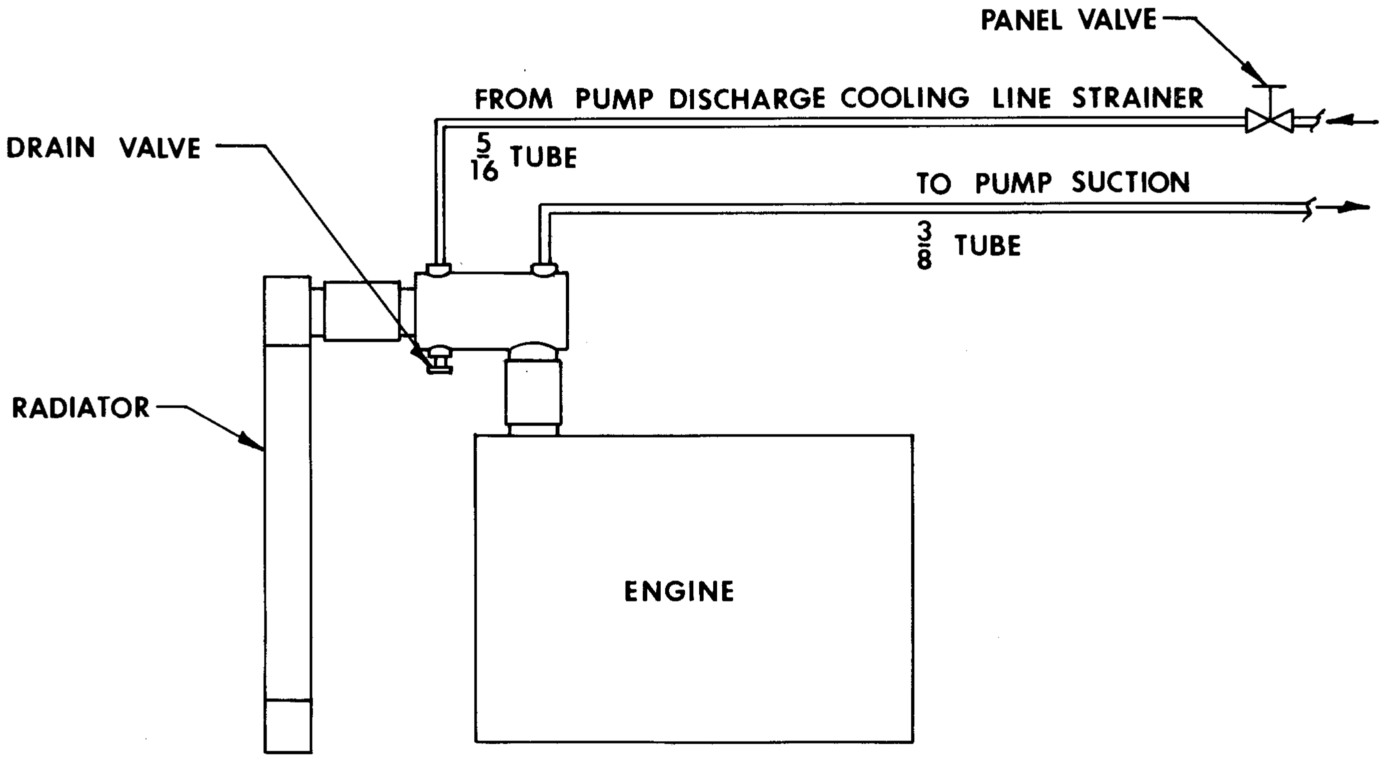
__PUMP SHIFT INSTALLATION:__ For power shift installation, refer to DGS1100 for automatic transmission wiring details.



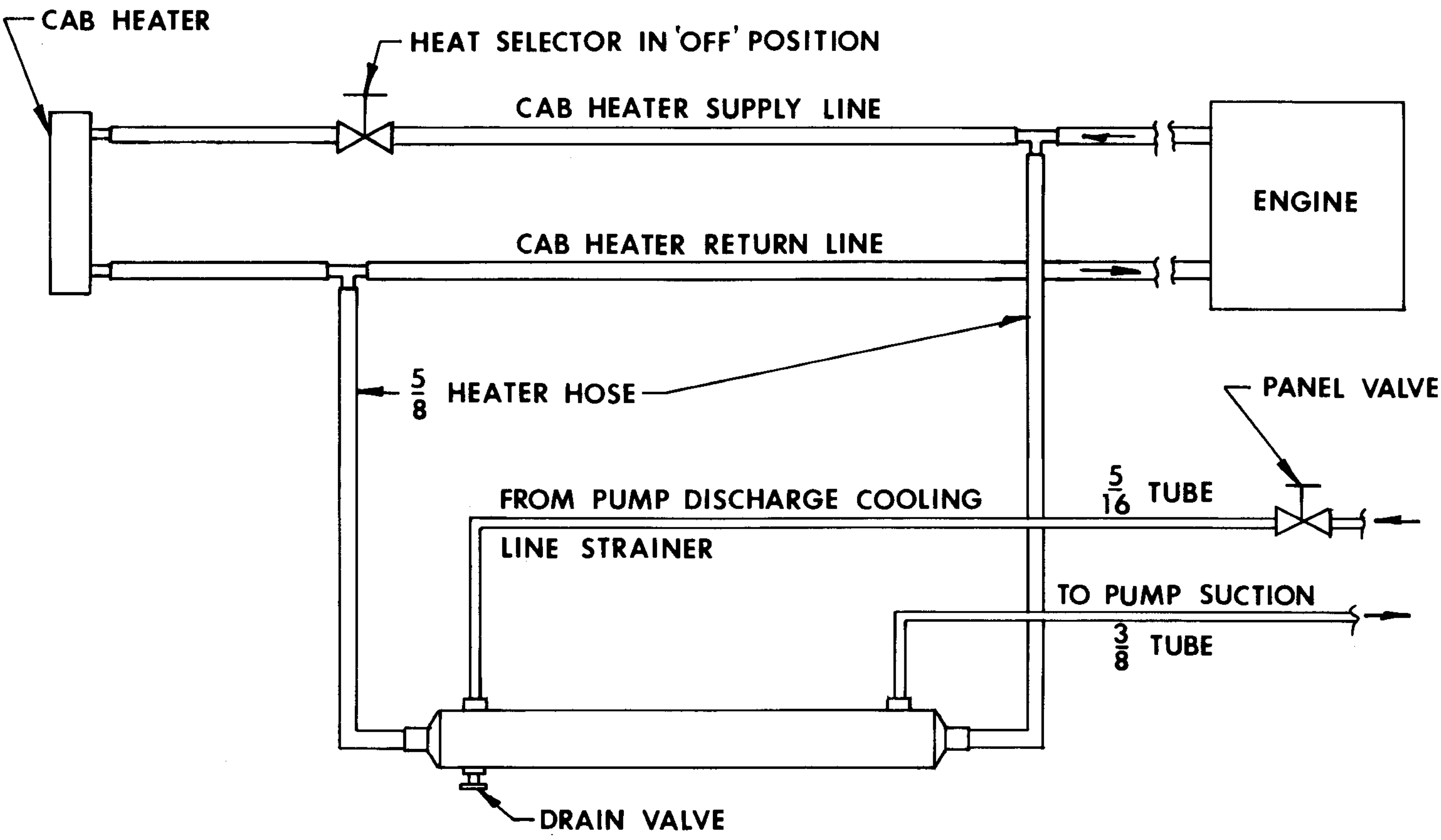
W.S. DARLEY & Co.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

DWG – HEAT EXCHANGER INSTALLATION SCHEMATIC

DATE NOV13,96
DRW'N BY TED
DGS0400

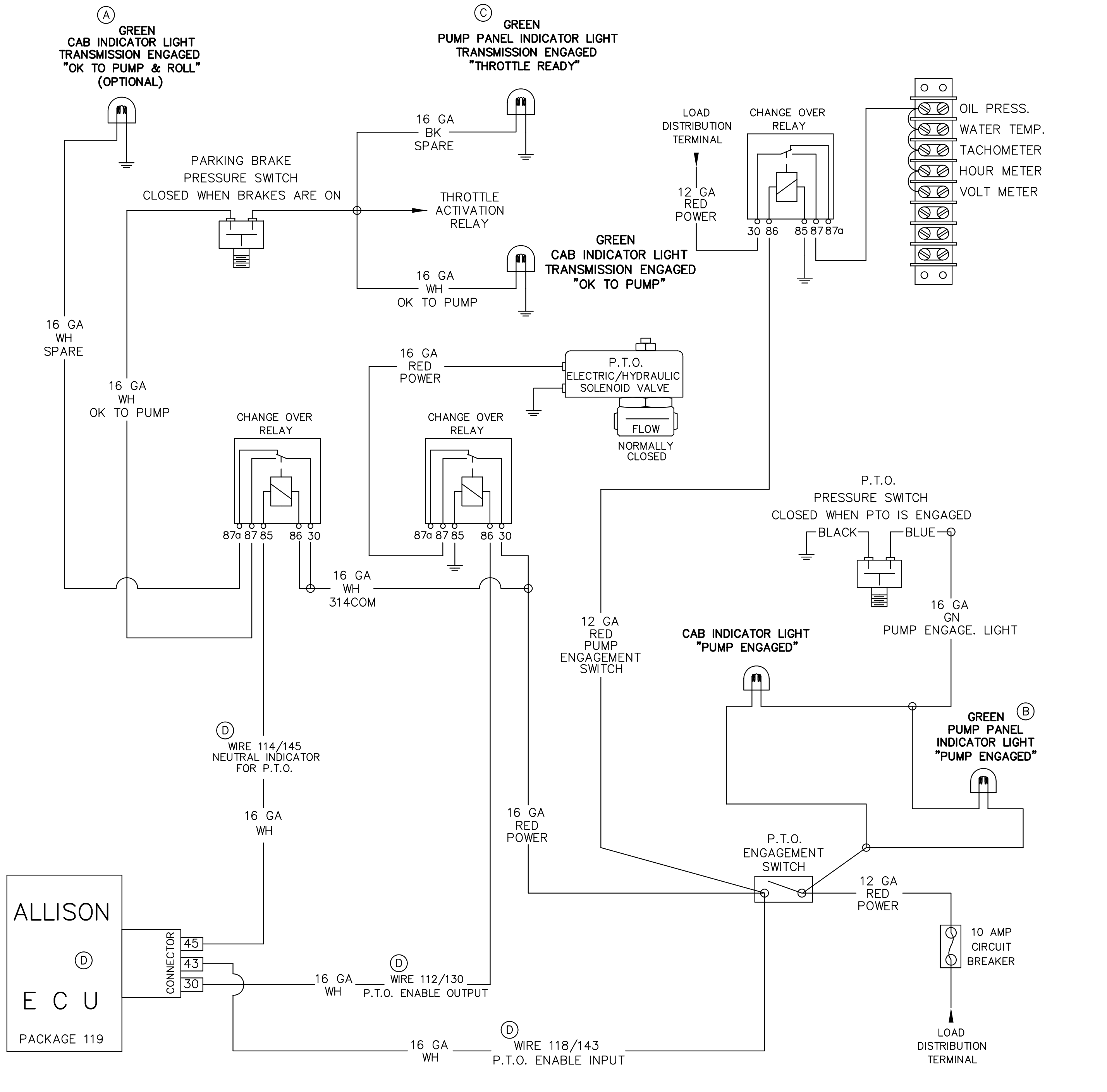


R592 HEAT EXCHANGER



F618 HEAT EXCHANGER

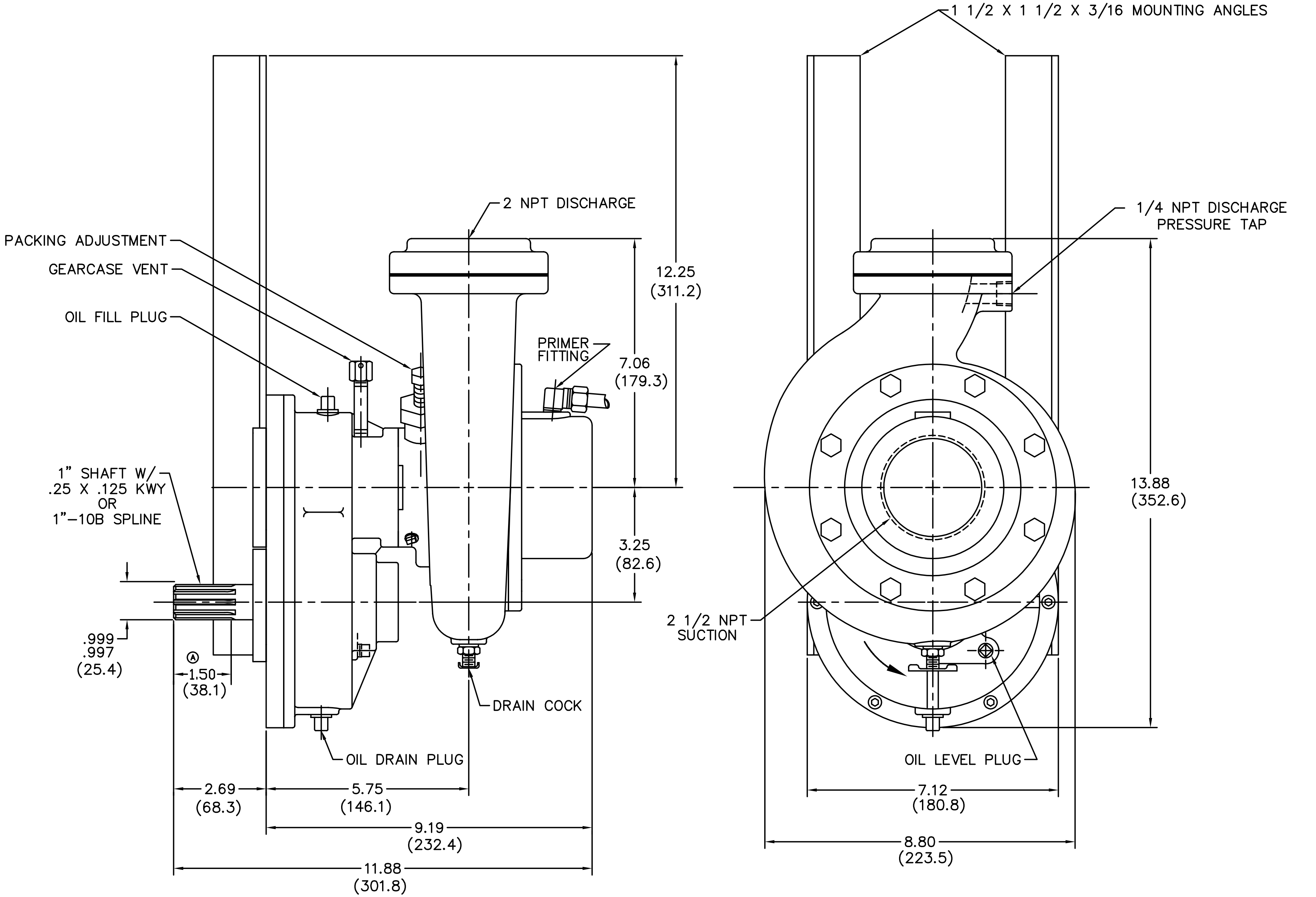
REVISIONS				
LTR	DESCRIPTION	DATE	CHG NO.	APPR'D
A	WAS: RED, PUMP PANEL "DANGER DO NOT OPEN THROTTLE"	20JAN00	00–11	DLW
B	ADDED LIGHT	20JAN00	00–11	DLW
C	WAS: GREEN, "WARNING: DO NOT OPEN THROTTLE UNLESS LIGHT IS ON"	20JAN00	00–11	DLW
D	ADDED NEWEST WIRE DESIGNATION #'s: 145, 143, 130; ADDED ALLISON E C U CONNECTOR #'s: 45, 43, 30;	6/23/08	2008–166	RJG



ELECTRICAL SCHEMATIC ALLISON WORLD TRANS. PTO/PUMP ENGAGEMENT

W.S. Darley & Co.
APPARATUS DIVISION
920 KURTH ROAD
CHIPPEWA FALLS, WISCONSIN 54729
1-715-726-2645

DWG BY SCHULTZ	SCALE SIZE A, 1:2	REV D
DATE 8-29-96	JOB NO.	DWG. NO. DGS1100



INCH (MM)

ENGINE ROTATION ONLY
APPROX. WEIGHT: 40 LBS. (18 Kg)

DMD	2000-51	03/13/00	A	WAS 1.75
APPR'D	CNG NO.	DATE		CHANGE

TOLERANCE EXCEPT AS NOTED
FRAC DIM ±.01
.00 ±.01
.000 ±.005
ANGLES ±1°

W.S. DARLEY & CO.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

DWG – 2.5 AG, PTO DIMENSIONAL

OLD PART NO. A642

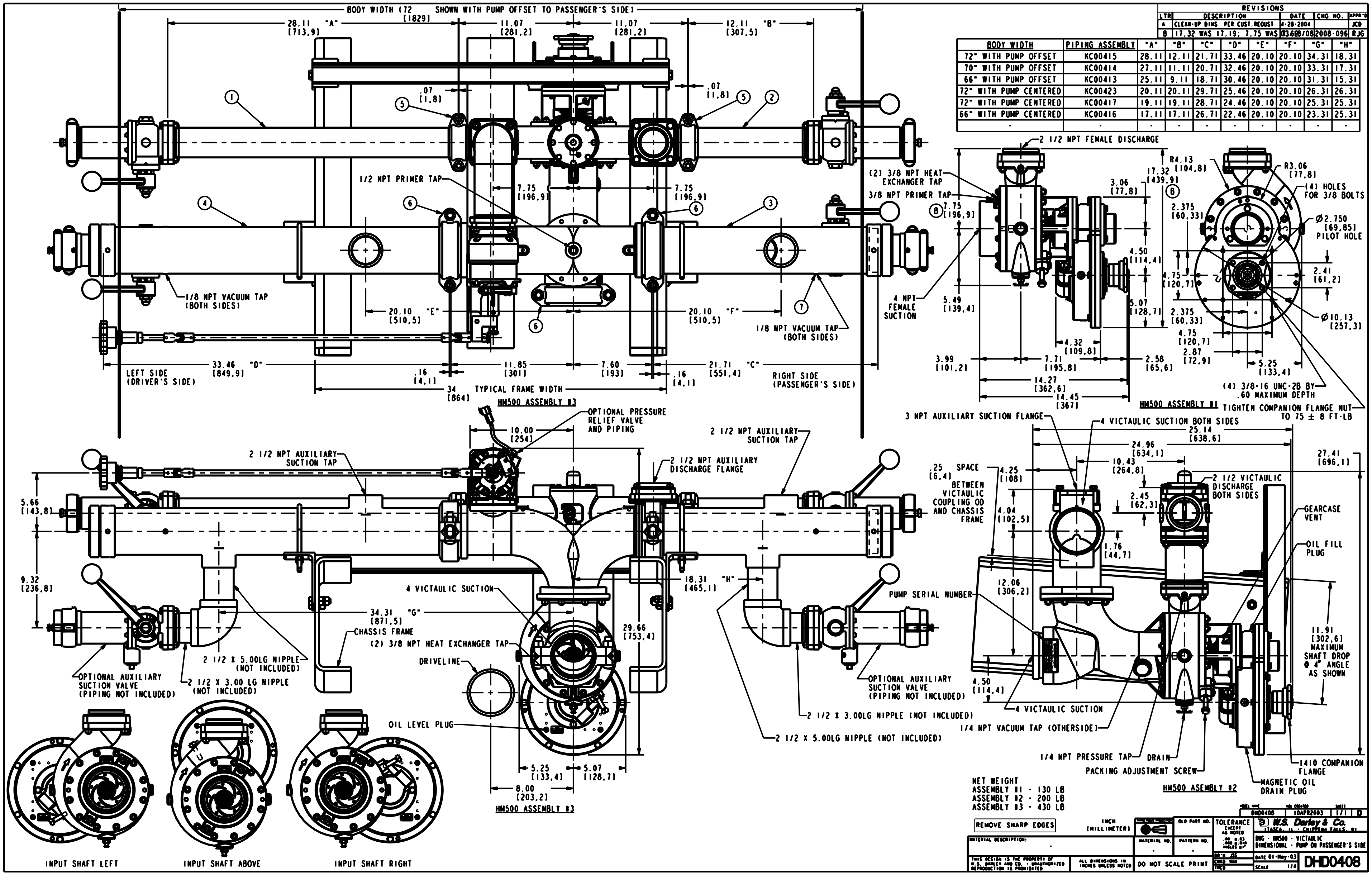
DR'N TED
CHKD
TRCD

DATE JUNE19,92
SCALE 1/2

DAD0200

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT



REVISIONS				
LTR	DESCRIPTION	DATE	CHG NO.	APPR'D
A	CLEAN-UP DIMS PER CUST.REQUST	4-28-2004		JCD
B	17.32 WAS 17.19; 7.75 WAS	[illegible]	2008-096	RJG

BODY WIDTH	PIPING ASSEMBLY	"A"	"B"	"C"	"D"	"E"	"F"	"G"	"H"
72" WITH PUMP OFFSET	KC00415	28.11	12.11	21.71	33.46	20.10	20.10	34.31	18.31
70" WITH PUMP OFFSET	KC00414	27.11	11.11	20.71	32.46	20.10	20.10	33.31	17.31
66" WITH PUMP OFFSET	KC00413	25.11	9.11	18.71	30.46	20.10	20.10	31.31	15.31
72" WITH PUMP CENTERED	KC00423	20.11	20.11	29.71	25.46	20.10	20.10	26.31	26.31
72" WITH PUMP CENTERED	KC00417	19.11	19.11	28.71	24.46	20.10	20.10	25.31	25.31
66" WITH PUMP CENTERED	KC00416	17.11	17.11	26.71	22.46	20.10	20.10	23.31	25.31
-	-	-	-	-	-	-	-	-	-

NET WEIGHT
ASSEMBLY #1 - 130 LB
ASSEMBLY #2 - 200 LB
ASSEMBLY #3 - 430 LB

REMOVE SHARP EDGES

INCH (MILLIMETER)

MODEL NAME: DHD0408 | MDL CREATED: 10APR2003 | SHEET: 1/1 | D

OLD PART NO. | MATERIAL NO. - | PATTERN NO. -

MATERIAL DESCRIPTION: -

TOLERANCE EXCEPT AS NOTED .00 ±.03 .000 ±.010 ANGLES ±1°

W.S. Darley & Co.
ITASCA, IL · CHIPPEWA FALLS, WI

DWG - HM500 - VICTAULIC
DIMENSIONAL - PUMP ON PASSENGER'S SIDE

DR'N JSS | CHK'D WAH | TRC'D

DATE 01-May-03 | SCALE 1/4

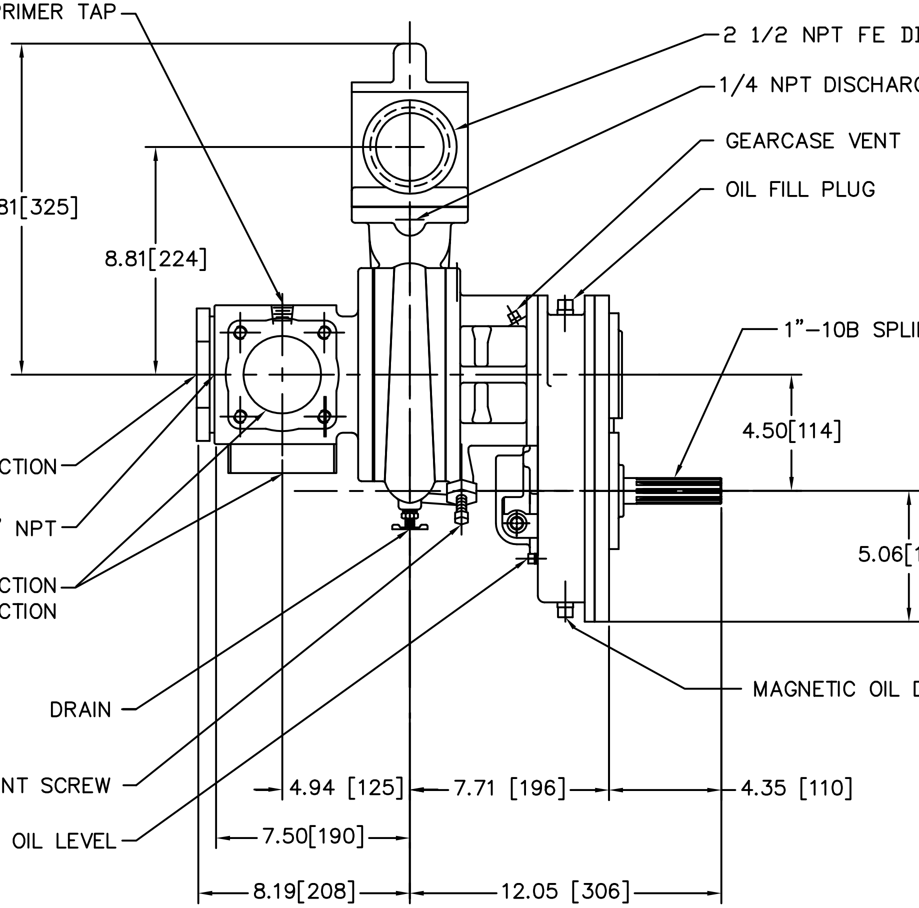
DHD0408

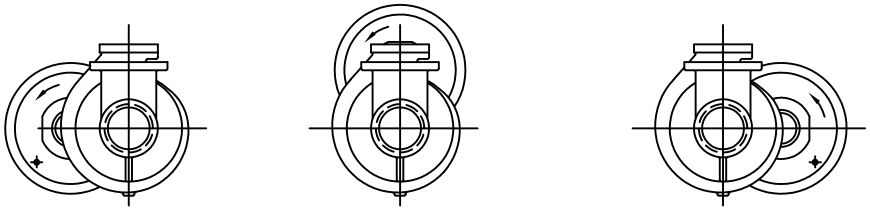
ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT

NAME:MJW OBJECT:DHD0408 DATE:27-Jul-09 16:12:15

REVISIONS				
LTR	DESCRIPTION	DATE	CHG NO.	APPR'D
A	UPDATED DRIVE SHAFT TO #5015600 UPDATED BRG.CAP TO #2303204 MODIFIED DIMS PER CUST. REQST.	04/28/04	–	JCD





INPUT SHAFT LEFT

INPUT SHAFT ABOVE

INPUT SHAFT RIGHT

OPTIONAL GEARCASE ROTATIONS

150 LBS
[68 KG]

INCH
[MILLIMETER]

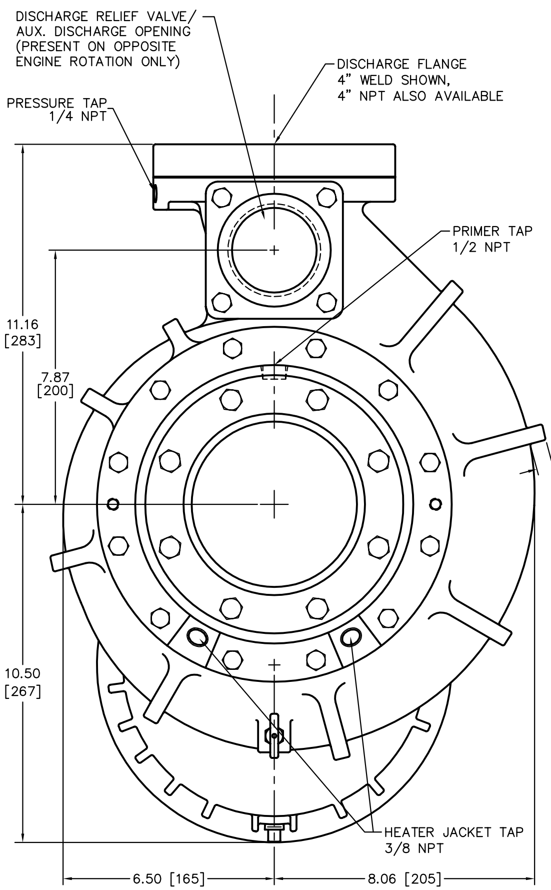
THIRD ANGLE PROJECTION

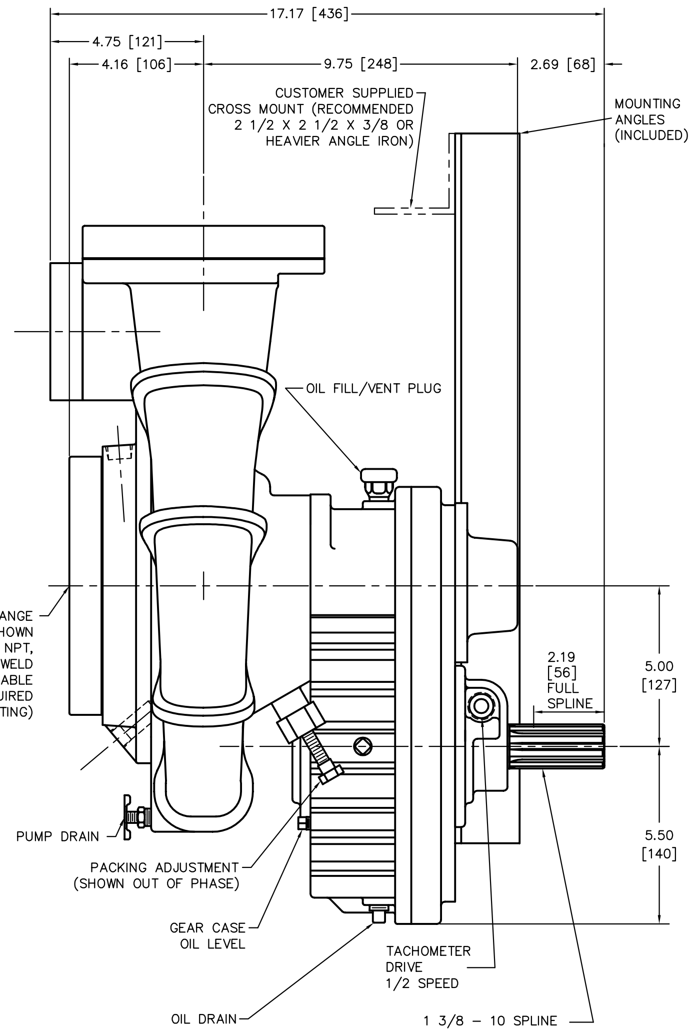
OLD PART NO. H469	TOLERANCE EXCEPT AS NOTED .00 ±.03 .000 ±.010 ANGLES ±1°	W.S. DARLEY & CO. MELROSE PARK, IL – CHIPPEWA FALLS, WI		
		DWG – HM250/350 –		
	DR'N TED	DATE NOV.29,95	DHD0406	
	CHKD	SCALE 1/4		
	TRCD			

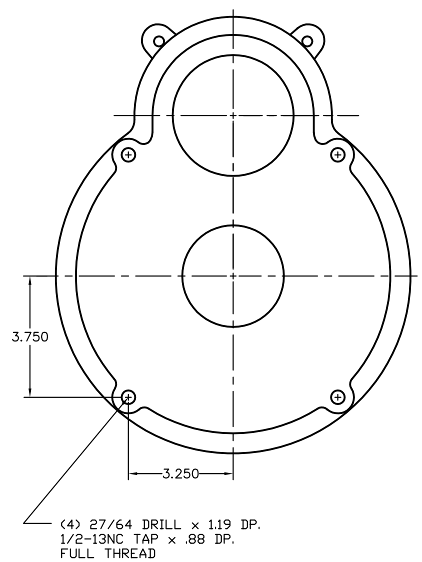
ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT

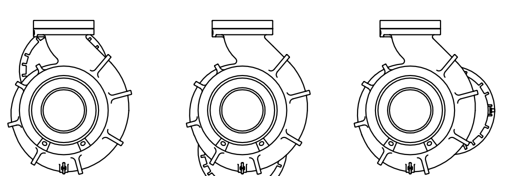
REVISIONS				
LTR	DESCRIPTION	DATE	CHG NO.	APPR'D
A	ADDED VIEW FOR MOUNTING HOLES	22JAN01	–	DMD







Ⓐ MOUNTING ANGLE HOLES



ROTATED 180° **STANDARD** ROTATED 90°

OPTIONAL GEAR CASE ORIENTATION

NOTE:
1) SUPPORT SUCTION AND/OR DISCHARGE PIPING. (ALLOW PIVOT POINTS FOR CHASSIS FLEXING.)
2) OPPOSITE ENGINE ROTATION SHOWN, ENGINE ROTATION IS ALSO AVAILABLE.
3) OVERALL HEIGHT AND WIDTH MAY VARY WITH THE TYPE OF DISCHARGE AND SUCTION.

NET WEIGHT: 215 lb.[98 kg.]

INCH
[MILLIMETER]

THIRD ANGLE PROJECTION

W.S. DARLEY & CO.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

KSP – DIMENSIONAL

OLD PART NO. K711

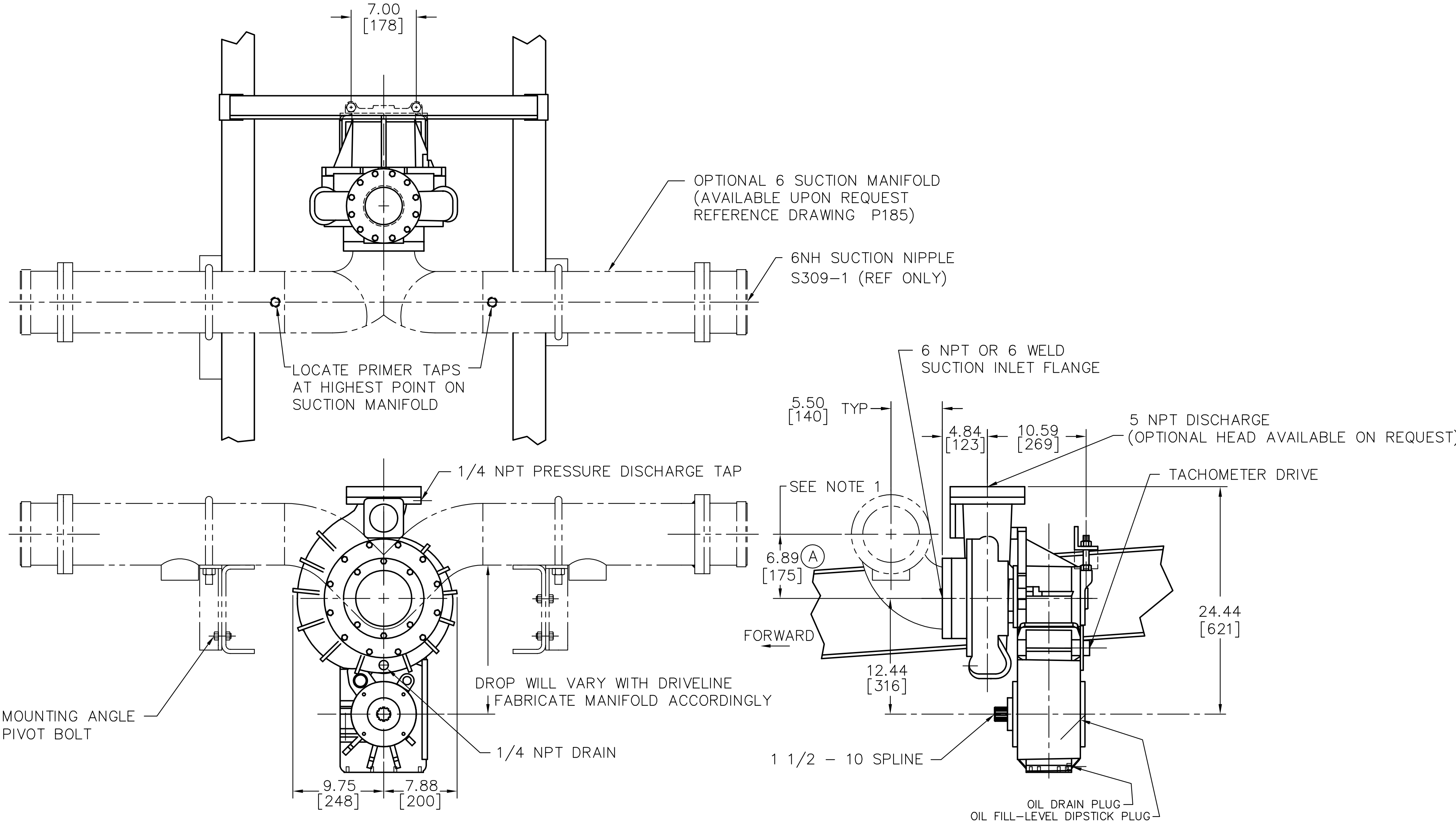
ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT

DR'N TED
CHKD
TRCD

DATE OCT22,93
SCALE 1/2

DKD0400



NOTE:

1) DIMENSION (A) IS REFERENCE TO A P185 MANIFOLD AND MAY VARY WITH DRIVELINE.

2) AVAILABLE IN PUMP FORWARD, OR PUMP REAR.

(B) UPDATED GEARCASE 9JUN00 TED

NET WEIGHT: 475 LBS [215 KG]

INCH [MILLIMETER]

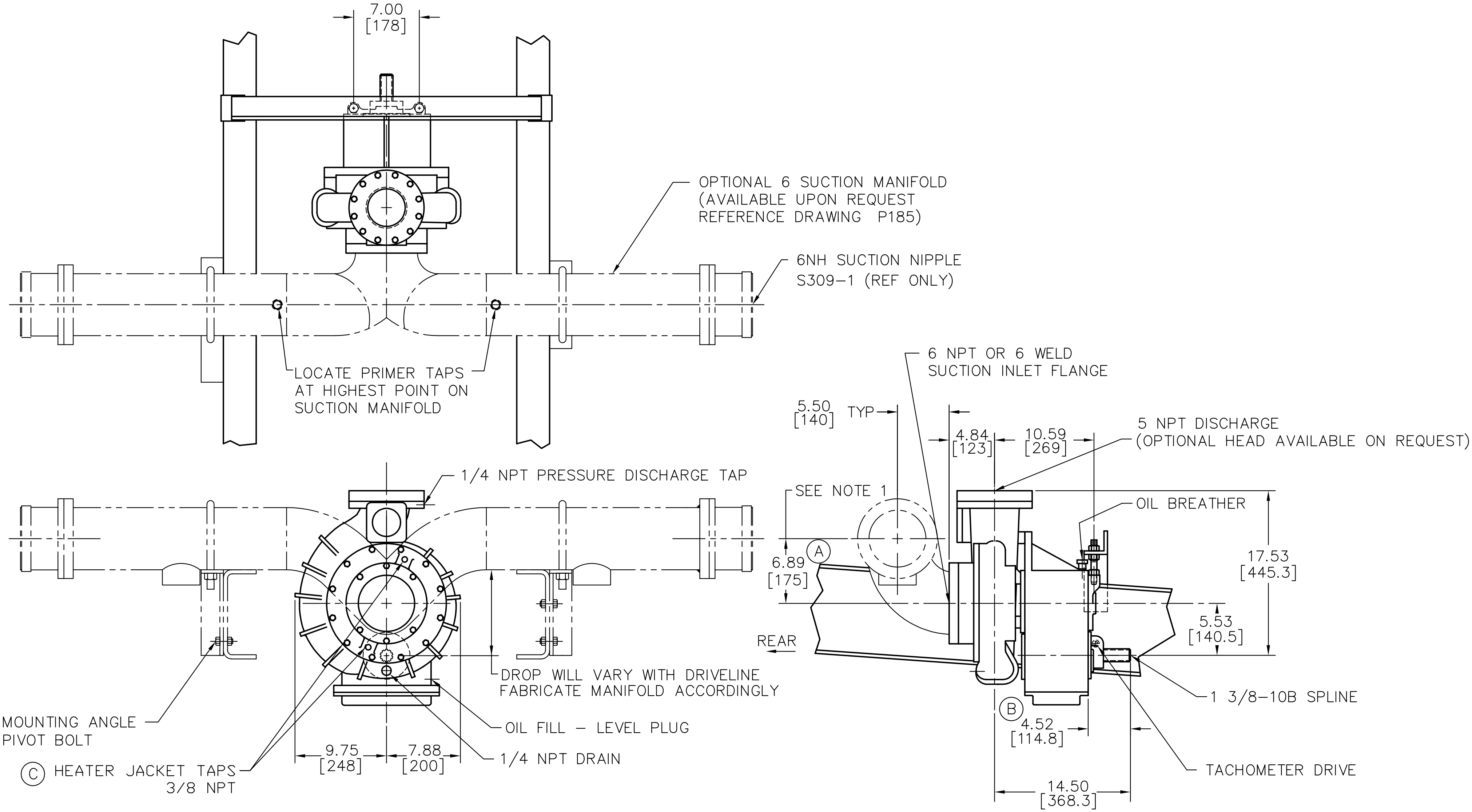
THIRD ANGLE PROJECTION

TOLERANCE EXCEPT AS NOTED FRAC DIM ±.01 .00 ±.01 .000 ±.005 ANGLES ±1°	W.S. DARLEY & CO. MELROSE PARK, IL - CHIPPEWA FALLS, WI	
OLD PART NO. P215	DWG - PSP, 3 GEAR DIMENSIONAL	
DR'N TED	DATE OCT12,92	DPD0400
CHKD	SCALE 1/8	
TRCD		

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT

REVISIONS				
LTR	DESCRIPTION	DATE	CHG NO.	APPR'D
B	ADDED DIMENSION OF SHAFT LENGTH	22JAN01	–	DMD
C	ADDED HEATER JACKET TAPS	22JAN01	–	DMD



INCH
[MILLIMETER]

THIRD ANGLE PROJECTION

NOTE:
1) DIMENSION (A) IS REFERENCE TO A P185 MANIFOLD AND MAY VERY WITH DRIVELINE.

NET WEIGHT: 345 LBS [155 KG]

TOLERANCE EXCEPT AS NOTED
FRAC DIM ±.01
.00 ±.01
.000 ±.005
ANGLES ±1°

OLD PART NO. P218

W.S. DARLEY & CO.
MELROSE PARK, IL – CHIPPEWA FALLS, WI

DWG – PSP, 2 GEAR DIMENSIONAL

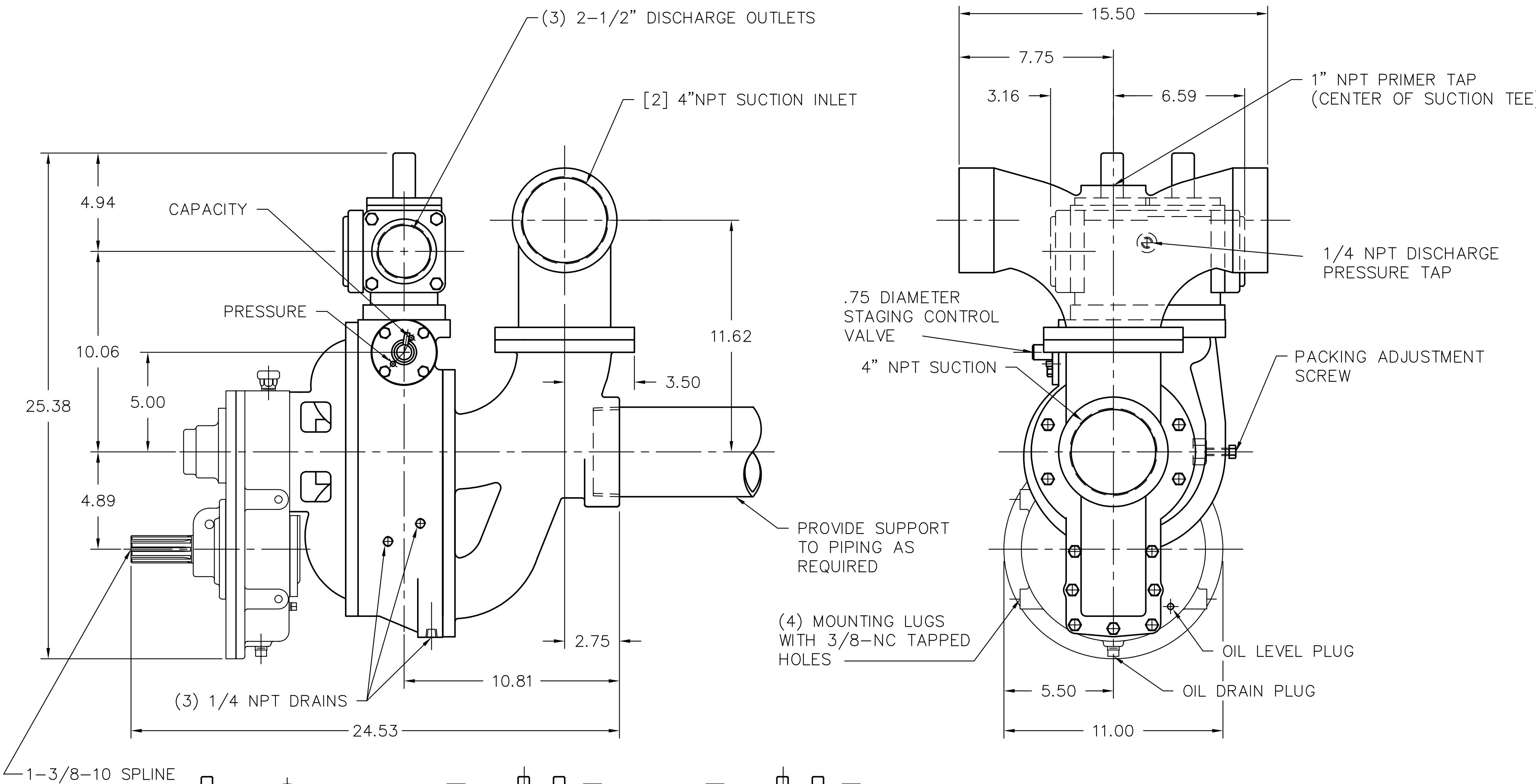
DR'N TED
CHKD
TRCD

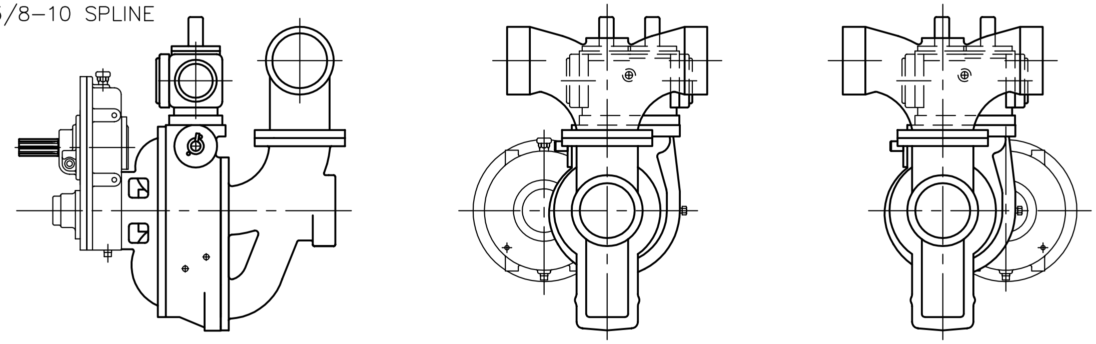
DATE MAR11,93
SCALE 1/8

DPD0500

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT





INPUT SHAFT ABOVE INPUT SHAFT LEFT INPUT SHAFT RIGHT

OPTIONAL GEARCASE ROTATIONS

APPROXIMATE WEIGHT - 300 LBS
136 KG

OLD PART NO.
J290

TOLERANCE EXCEPT AS NOTED
FRAC DIM ±.01
.00 ±.01
.000 ±.005
ANGLES ±1°

W.S. DARLEY & CO.
MELROSE PARK, IL - CHIPPEWA FALLS, WI

JMP500 OPPOSITE ROTATION
ENGINE ROTATION /TACH. DRIVE

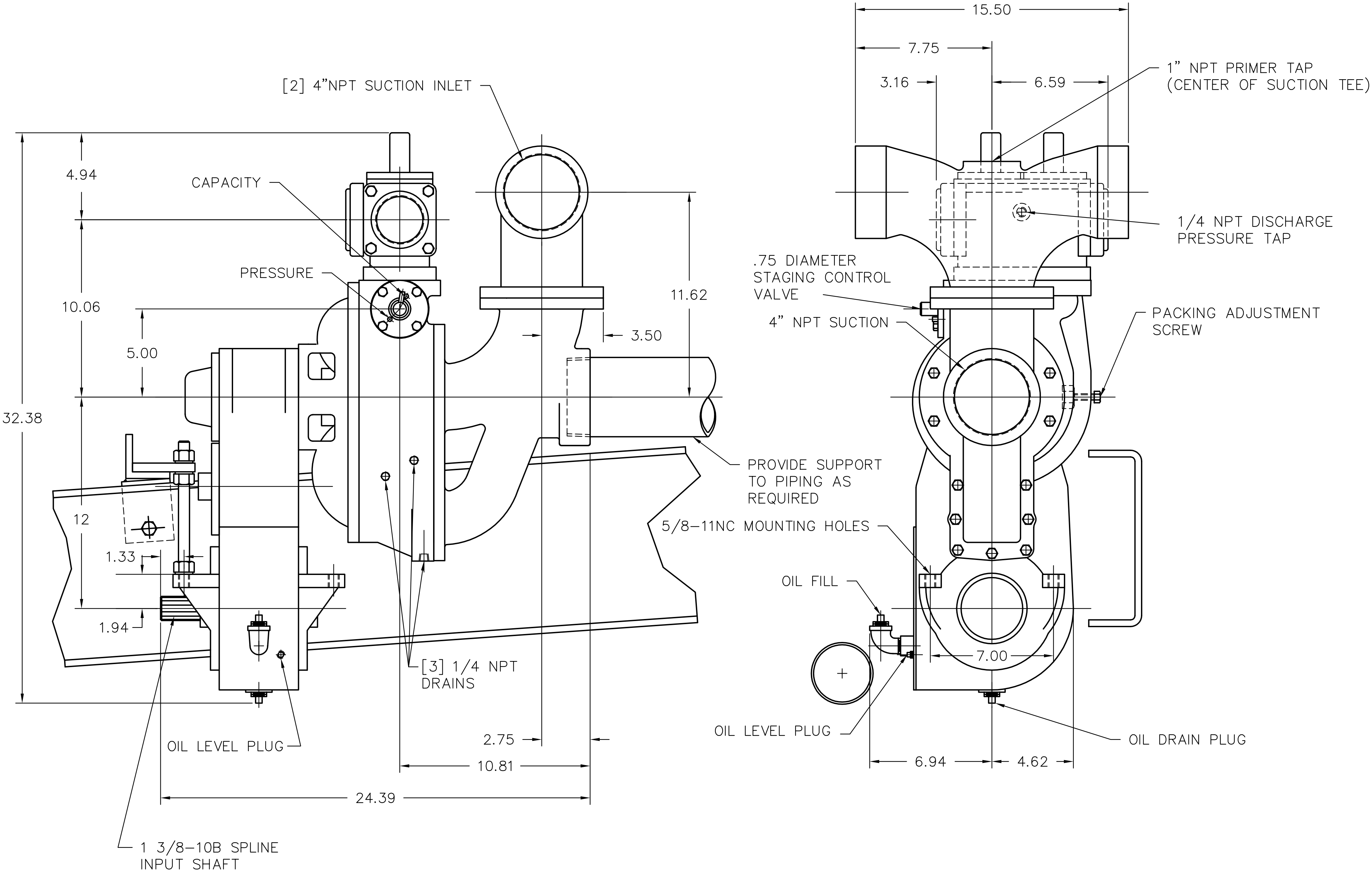
DR'N S.LEE/TED
CHKD
TRCD

DATE AUG.9,94
SCALE 1/4

DJD0300

ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT



APPROXIMATE WEIGHT – 415 LBS
188 KG

TOLERANCE EXCEPT AS NOTED FRAC DIM ±.01 .00 ±.01 .000 ±.005 ANGLES ±1°	W.S. DARLEY & CO. MELROSE PARK, IL – CHIPPEWA FALLS, WI	
OLD PART NO. J273	DWG – JMP, 3 GEAR, ENG ROT DIMENSIONAL	
DR'N SEITZ	DATE OCT05,88	DJD0400
CHKD	SCALE 1/4	
TRCD		

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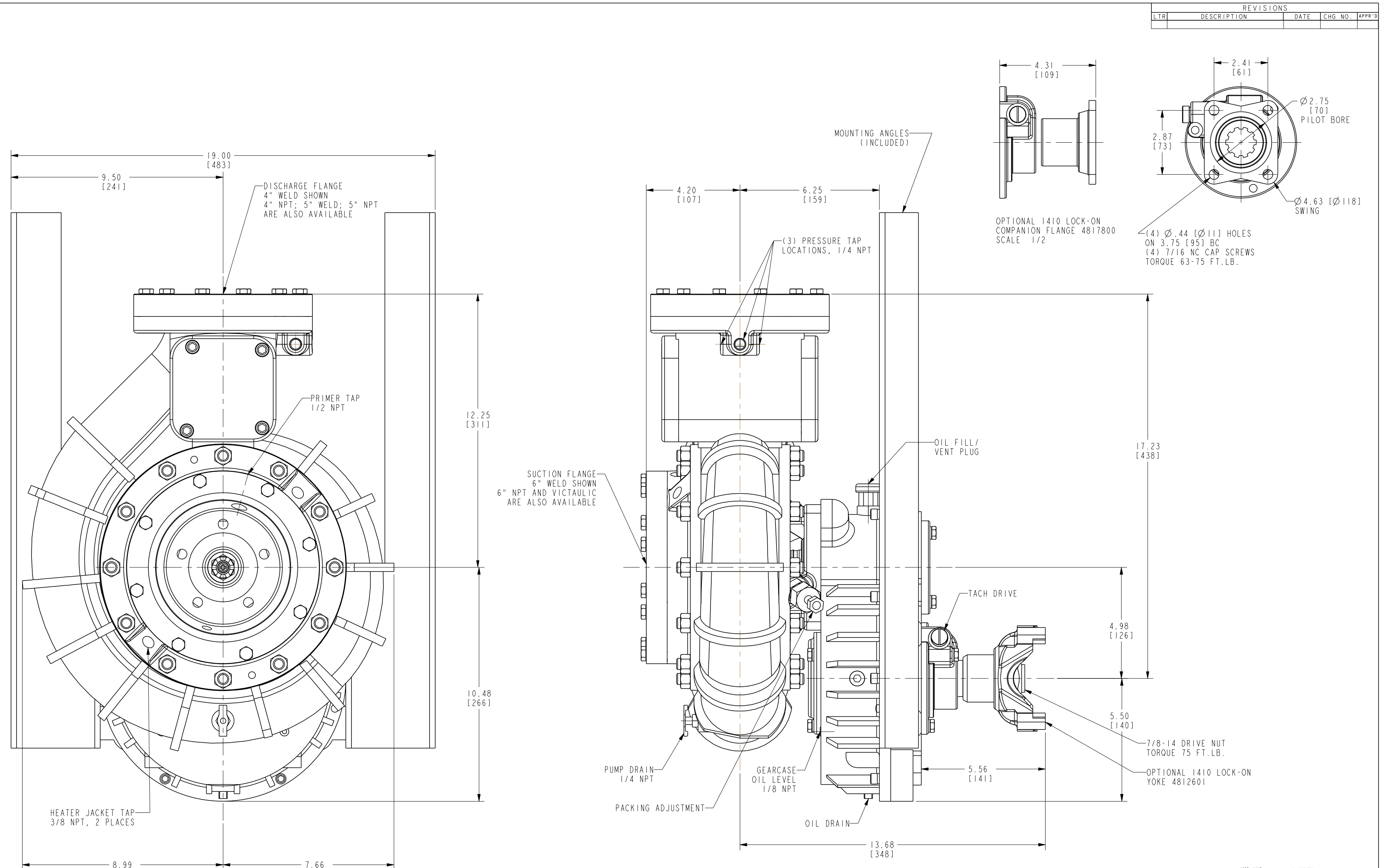
ALL DIMENSIONS IN INCHES UNLESS NOTED

DO NOT SCALE PRINT



MODEL NAME	MDL CREATED	SHEET	
DLD0800	5/14/03	1/1	D

REMOVE SHARP EDGES

INCH
[MILLIMETER]

THIRD ANGLE PROJECTION

OLD PART NO.

TOLERANCE
EXCEPT AS NOTED
.00 ±.03
.000 ±.010
ANGLES ±1°

W.S. Darley & Co.
CHIPPEWA FALLS, WI - MELROSE PARK, IL

LSP 2 GEAR, LOCK-ON
DIMENSIONAL

MATERIAL DESCRIPTION: -

MATERIAL NO. -

PATTERN NO. -

DR'N JSS
CHKD CKE
TRCD

DATE 14-May-03
SCALE 1/2

DLD0800

ALL DIMENSIONS IN INCHES UNLESS NOTED

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Appendix to Installation

Prepared by: EAS
Approved by: TED
Revised by: CWY

Rev. A
Date: 03/16/12
Rev. Date: 06/20/13
1201009.doc

SPICER®
DRIVETRAIN COMPONENTS
DANA

DRIVELINE INSTALLATION

J3311-1-DSSP
AUGUST 2008

Supersedes
J3311-1-HVTSS, Dated
February 2005

DANA SPICER®
Drivetrain Products

General Safety Information

To prevent injury to yourself and /or damage to the equipment:

- Read carefully all owners manuals, service manuals, and/or other instructions.
- Always follow proper procedures and use proper tools and safety equipment.
- Be sure to receive proper training.
- Never work alone while under a vehicle or while repairing or maintaining equipment.
- Always use proper components in applications for which they are approved.
- Be sure to assemble components properly.
- Never use worn-out or damaged components.
- Always block any raised or moving device that may injure a person working on or under a vehicle.
- Never operate the controls of the power take-off or other driven equipment from any position that could result in getting caught in the moving machinery.

WARNING: ROTATING DRIVESHAFTS

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.

WARNING: GUARDING AUXILIARY DRIVESHAFTS

We strongly recommend that a power take-off and a directly mounted pump be used to eliminate the auxiliary driveshaft whenever possible. If an auxiliary driveshaft is used and remains exposed after installation, it is the responsibility of the vehicle designer and PTO installer to install a guard.

WARNING: USING SET SCREWS

Auxiliary driveshafts may be installed with either recessed or protruding set screws. If you choose a square head set screw, you should be aware that it will protrude above the hub of the yoke and may be a point where clothes, skin, hair, hands, etc. could be snagged. A socket head set screw, which may not protrude above the hub of the yoke, does not permit the same amount of torquing as does a square head set screw. Also a square head set screw, if used with a lock wire, will prevent loosening of the screw caused by vibration. Regardless of the choice made with respect to a set screw, an exposed rotating auxiliary driveshaft must be guarded.

WARNING: THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

Introduction

This brochure is intended for:

- Installers who install Spicer driveshafts into an application where the transmission and axle are not in direct line with each other, causing the driveshaft universal joints to operate at an angle.
- Anyone experiencing vibration problems with their application or their vehicle that driveshaft assembly balancing will not correct.
- Truck Equipment Distributors who:
  - Re-work a chassis to change the wheel base.
  - Install a midship mounted power take-off or fire pump.
  - Mount any other PTO-driven device such as a blower, hydraulic pump, or hydraulic motor.

Universal joint failures, as a rule, are of a progressive nature, which, when they occur, generally accelerate rapidly resulting in a mass of melted trunnions and bearings.

Some recognizable signs of universal joint deterioration are:

1. Vibrations - Driver should report to maintenance.
2. Universal joint looseness - End play across bearings.
3. Universal joint discoloration due to excessive heat build-up.
4. Inability to purge all four trunnion seals when re-lubing universal joint.

Items 2) thru 4) should be checked at re-lube cycle and, if detected, reported to the maintenance supervisor for investigation.

Experience with universal joint failures has shown that a significant majority are related to lubricating film breakdown. This may be caused by a lack of lubricant, inadequate lube quality for the application, inadequate initial lubrication, or failure to lubricate properly and often enough.

Failures which are not the result of lubrication film breakdown are associated with the installation, angles and speeds, and manufacturing discrepancies.

Driveshaft failures through torque, fatigue, and bending are associated with overload, excessively high universal joint angles, and drive shaft lengths excessive for operating speeds.

Driveshaft Torque

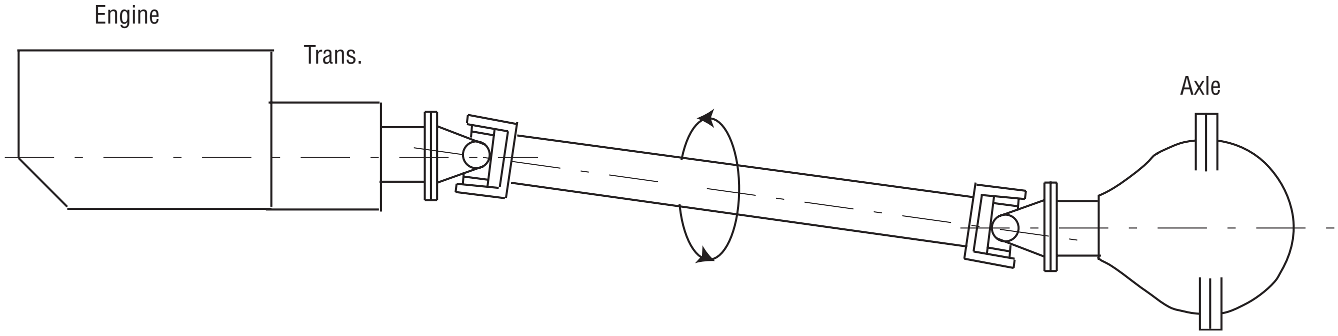
The following problems are usually a result of torque overloads:

Twisted driveshaft tube

Broken yoke shaft, slip yoke, tube yoke, flange yoke, end yoke

Broken journal cross

How much torque can be generated in your application?



How to Calculate Torque:

LGT = T x TLGR x TE x SR x TCR x C

LGT = Maximum Driveshaft Low Gear Torque

T = Net Engine Torque or 95% of the Gross Engine Torque

TLGR = Transmission Low Gear Ratio (forward)*

TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

C = Transfer Case Efficiency (if applicable, 0.95)

How to Calculate Wheel Slip:

WST = (.71 x W x RR) / (11.4 x AR)

WST = Wheel Slip Torque Applied to the Driveshaft

W = Axle Capacity (lbs)

RR = Tire Rolling Radius (in)

AR = Axle Ratio

For On Road Applications

Relate the lesser of above to Spicer universal joint ratings. If your torque exceeds the Spicer rating for the universal joint used in your application, switch to a size with a rating compatible to your calculation. However, the series selected cannot be more than one series below the series called for by the LGT calculation.

For Off Road or On-Off Road Applications

Use Low Gear Torque value only to verify or switch to a size with a rating compatible to your calculation.

Common Causes of Vibrations

The three most common causes of driveshaft vibration are: Driveshaft Imbalance, Critical Speed, and Universal Joint Operating Angles.

Driveshaft Imbalance

Eliminate the potential for balance problems before you undertake any other measures.

A driveshaft on a vehicle usually rotates at a higher rate of speed than the tire. For that reason, like tires, driveshafts should be balanced.

Any time you build or rework a driveshaft, make sure it is dynamically balanced at, 3000 RPM for Light Duty or 2500 RPM for Heavy Duty, to the following specifications:

Series	Specification
1310, 1330	.375 oz-in total at each end of shaft *
1350, 1410	.500 oz-in total at each end of shaft *
1480 - 1880	1.00 oz-in for each ten pounds of driveshaft weight divided proportionally at each end of shaft
* Passenger Car, Light Truck, Van, and SUV only. Industrial, Mobile Off-Highway, PTO, etc. same as 1480 - 1880.	

Critical Speed

Every driveshaft has a critical speed. Critical speed is the point at which a rotating driveshaft begins to bow off its normal rotating centerline.

Driveshafts begin to vibrate as they approach critical speed. If they are operated at near critical speed for an extended period, they often fail. This can damage the vehicle and possibly injure persons nearby.

As a driveshaft fabricator or installer, you are responsible for checking the safe operating speed of any driveshaft you fabricate or specify into an application. Make sure it will not operate at a speed higher than Spicer's recommended safe operating speed. Use Spicer Calculator (P/N J 3253) to determine safe operating speed.

Checking for a Possible Critical Speed Problem

Here is what you must do to make sure you won't have a critical speed problem:

- Determine the safe operating speed of the driveshaft you want to use in your application. Insert the tube diameter and center-to-center installed length of the shaft you want to use into a Spicer Safe Operating Speed Calculator (P/N. J3253). The calculator will tell you the safe operating speed of the shaft you have chosen.
- Determine the NORMAL and MAXIMUM POSSIBLE operating speed of the driveshaft.
  REMEMBER:
  - On vehicles with a standard transmission that have a 1:1 direct drive high gear and no overdrive, MAXIMUM POSSIBLE driveshaft RPM is the same as the maximum possible ENGINE RPM.
  - On vehicles that have an overdrive transmission, MAXIMUM POSSIBLE driveshaft RPM is higher than maximum possible ENGINE RPM.

Maximum Possible Driveshaft RPM

To calculate the maximum possible driveshaft RPM in vehicles having an overdrive transmission, divide the maximum possible engine RPM by the overdrive ratio. (See examples below.)

Example 1:
Max. engine RPM: 2100
Overdrive ratio: .79
2100/.79 = 2658 maximum possible driveshaft RPM

Example 2:
Max. engine RPM 6000
Overdrive ratio: .66
6000/.66 - 9091 maximum possible driveshaft RPM

Compare the maximum possible driveshaft RPM with the safe operating speed determined from the Safe Operating Speed Calculator. If the maximum possible driveshaft RPM meets or exceeds the safe operating speed determined from the calculator, you must do whatever is required to raise the critical speed of the driveshaft you have chosen for the application.

Sample Specification:

To specify a driveshaft for the application described in Example 1 above, compare the safe operating speed for the driveshaft selected with the maximum possible driveshaft RPM calculated (2658 RPM). Make sure the safe operating speed of the driveshaft is greater than 2658 RPM.

Changing the Safe Operating Speed of a Driveshaft

A driveshaft's safe operating speed can be raised by increasing its tube diameter or by shortening the installed center-to-center length of the driveshaft. Changing the installed length of a driveshaft will require the use of multiple driveshafts with center bearings.

Important: The critical speed of an assembly can be affected by driveshaft imbalance, improper universal joint operating angles, or improperly phased driveshafts. (A properly phased driveshaft has the in-board yokes of the shaft in line with each other.) Each of the above items will tend to lower the true critical speed from the values shown on the calculator.

Since critical speed can ultimately cause driveshaft failure, it is extremely important to be very precise in all applications.

Universal Joint Operating Angles

Every Universal Joint that Operates at an Angle Creates a Vibration

Universal joint operating angles are probably the most common causes of driveline vibration in vehicles that have been reworked, or in vehicles that have had auxiliary equipment installed.

Universal joint operating angles are a primary source of problems contributing to:

- Vibrations
- Reduced universal joint life
- Problems with other drivetrain components that may include:
  - Transmission gear failures
  - Synchronizer failures
  - Differential problems
  - Premature seal failures in axles, transmissions, pumps, or blowers
  - Premature failure of gears, seals, and shafts in Power Take-Offs

When you rework a chassis or install a new driveshaft in a vehicle, make sure that you follow the basic rules that apply to universal joint operating angles:

RULE 1: UNIVERSAL JOINT OPERATING ANGLES AT EACH END OF A DRIVESHAFT SHOULD ALWAYS BE AT LEAST 1 DEGREE.

RULE 2: UNIVERSAL JOINT OPERATING ANGLES ON EACH END OF A DRIVESHAFT SHOULD ALWAYS BE EQUAL WITHIN 1 DEGREE OF EACH OTHER (ONE HALF DEGREE FOR MOTOR HOMES AND SHAFTS IN FRONT OF TRANSFER CASE OR AUXILIARY DEVICE).

RULE 3: FOR VIRTUAL VIBRATION FREE PERFORMANCE, UNIVERSAL JOINT OPERATING ANGLES SHOULD NOT BE LARGER THAN 3 DEGREES. IF THEY ARE, MAKE SURE THEY DO NOT EXCEED THE MAXIMUM RECOMMENDED ANGLES.

A universal joint operating angle is the angle that occurs at each end of a driveshaft when the output shaft of the transmission and driveshaft and the input shaft of the axle and driveshaft are not in line. (See Fig 1)

The connecting driveshaft operates with an angle at each universal joint. It is that angle that creates a vibration.

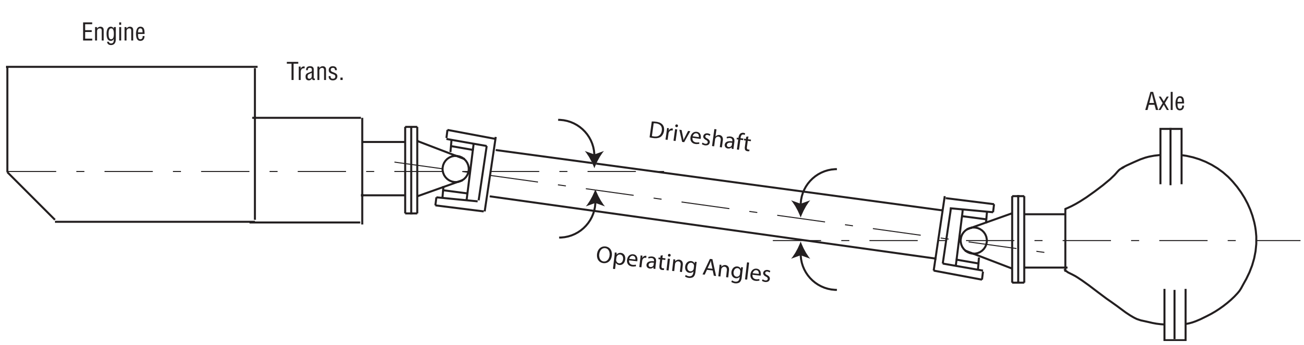


Figure 1

Reducing and Canceling Vibration

A key point to remember about universal joint operating angles: To reduce the amount of vibration, the angles on each end of a driveshaft should always be SMALL.

To cancel an angle vibration, the universal joint operating angles need to be EQUAL within 1 degree at each end of a driveshaft. On motor home applications and auxiliary transmission installations, the tolerance is 1/2 degree. (See Fig 2)

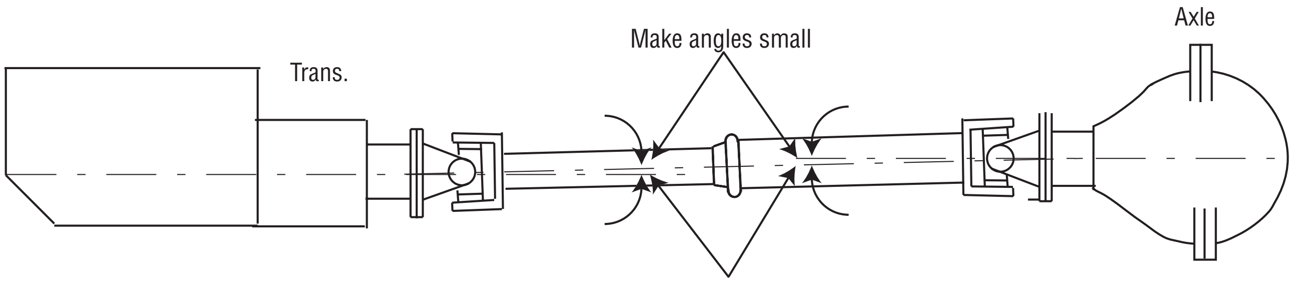


Figure 2

Single Plane and Compound Universal Joint Operating Angles

There are two types of universal joint operating angles: Single Plane and Compound.

Single Plane

Single Plane angles occur when the transmission and axle components are in line when viewed from either the top or side, but not both.

Determining the universal joint operating angle in an application where the components are in line when viewed from the top, but not in line when viewed from the side, is as simple as measuring the slope of the components in the side view, and adding or subtracting those slopes to determine the angle. (See Fig. 3)

These angles should be **small** and **equal** within 1 degree.

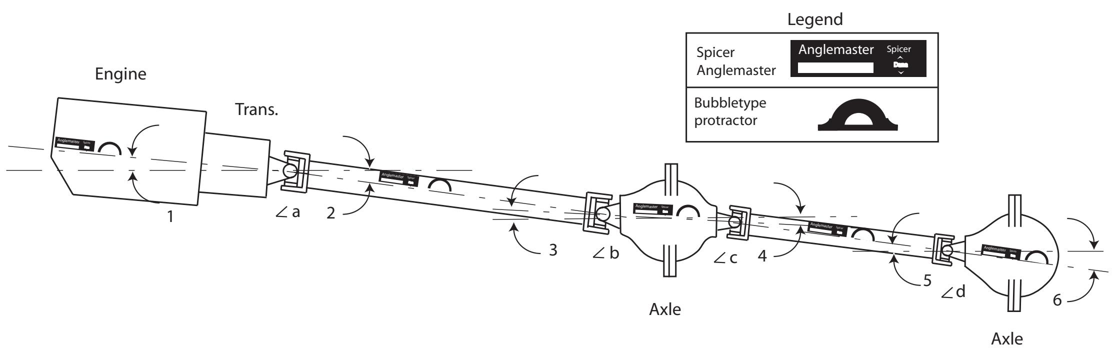


Figure 3

The most convenient way to determine universal joint angles in the side view is through the use of a Spicer Anglemaster™ or a bubble type protractor.

Using an Anglemaster or a bubble protractor, record inclination angles of drivetrain components. Set Anglemaster or protractor on machined surfaces of engine, transmission, axle, or on machined lugs of transmission and axle yoke(s).

Note: Universal joint angles can change significantly in a loaded situation. Therefore, check vehicle loaded and unloaded to achieve the accepted angle cancellation.

<u>Example:</u>

Engine-Transmission Output	4°30’ Down (1)
Main Driveshaft	7°00’ Down (2)
Input 1st Rear Axle	4°00’ Up (Input Shaft Nose Up) (3)
Output 1st Rear Axle	4°00’ Down (4)
Inter-axle Shaft	7°00’ Down (5)
Input 2nd Rear Axle	4°15’ Up (Pinion Shaft Nose Up) (6)
Note: If inclination of driveshaft is opposite connecting component, add angles to obtain the universal joint operating angle.	
Angle a = (2) - (1) = 7°00’ - 4°30’ = 2°30’ (2.50°)	
Angle b = (2) - (3) = 7°00’ - 4°00’ = 3°00’ (3.00°)	
Angle c = (5) - (4) = 7°00’ - 4°00’ = 3°00’ (3.00°)	
Angle d = (5) - (6) = 7°00’ - 4°15’ = 2°45’ (2.75°)	

Determining the universal joint operating angles on a driveshaft that is straight when viewed from the side and offset when viewed from the top requires the use of a special chart (See Angle Chart). In this type of application, the centerlines of the connected components **must be parallel** when viewed from the top as shown. These angles also should be **small** and **equal** within 1 degree. (See Fig. 4)

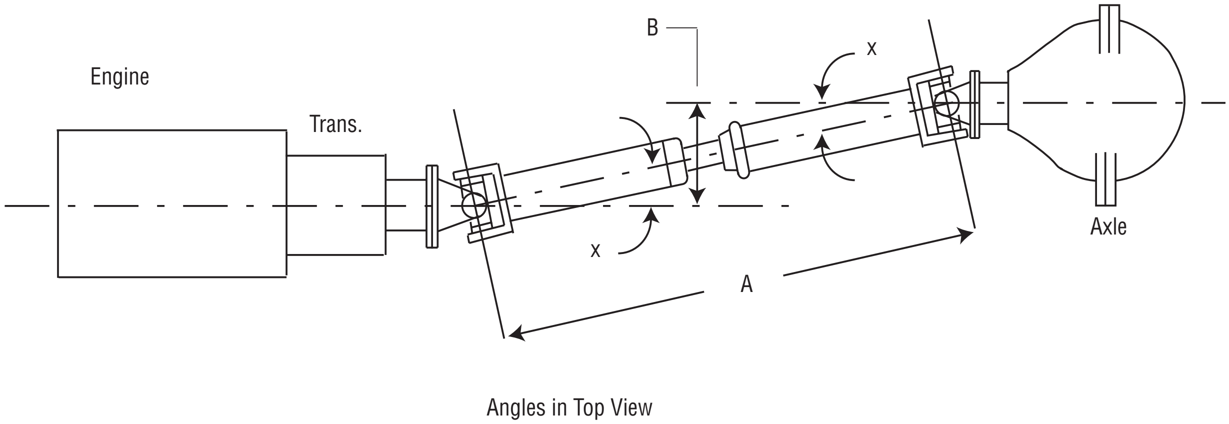


Figure 4

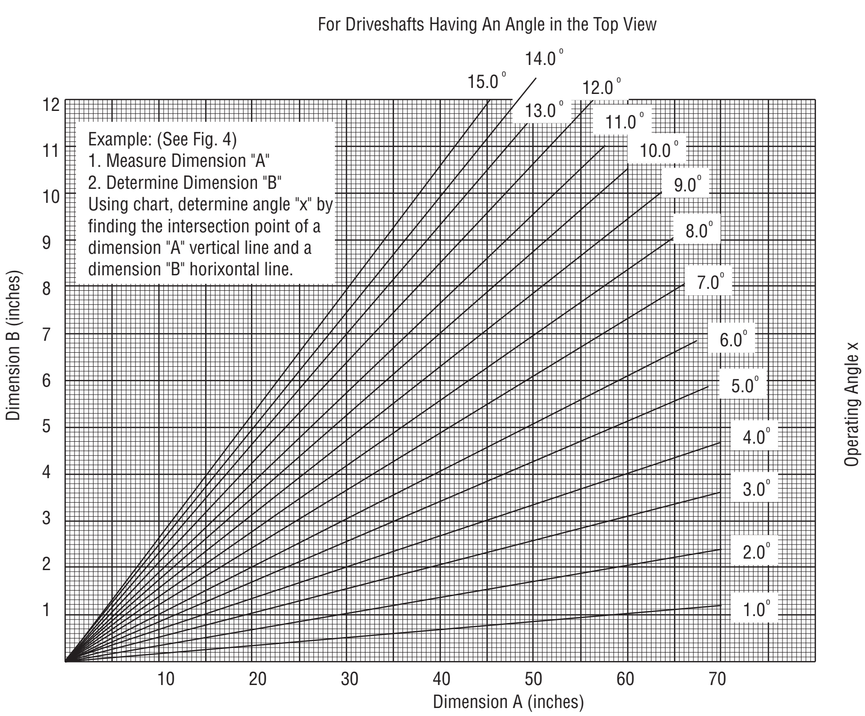
Measure dimensions "A" and "B" shown in figure 4. Use the instructions in the angle chart below to determine the size of the angle.

Look at the Angle Chart and note that the smaller the offset, the smaller the resultant angle.

To reduce the possibility of vibration, keep any offset between connected points to a minimum.

There are two things you can do to always make sure Single Plane angles are SMALL and EQUAL: Make sure the transmission and axle are mounted so their centerlines are parallel when viewed from both the side and the top. Make sure the offset between them is small in both views.

ANGLE CHART



Compound Angles

Compound universal joint operating angles occur when the transmission and axle are not in line when viewed from BOTH the top and side. Their centerlines, however, are parallel in both views. (See Fig. 5)

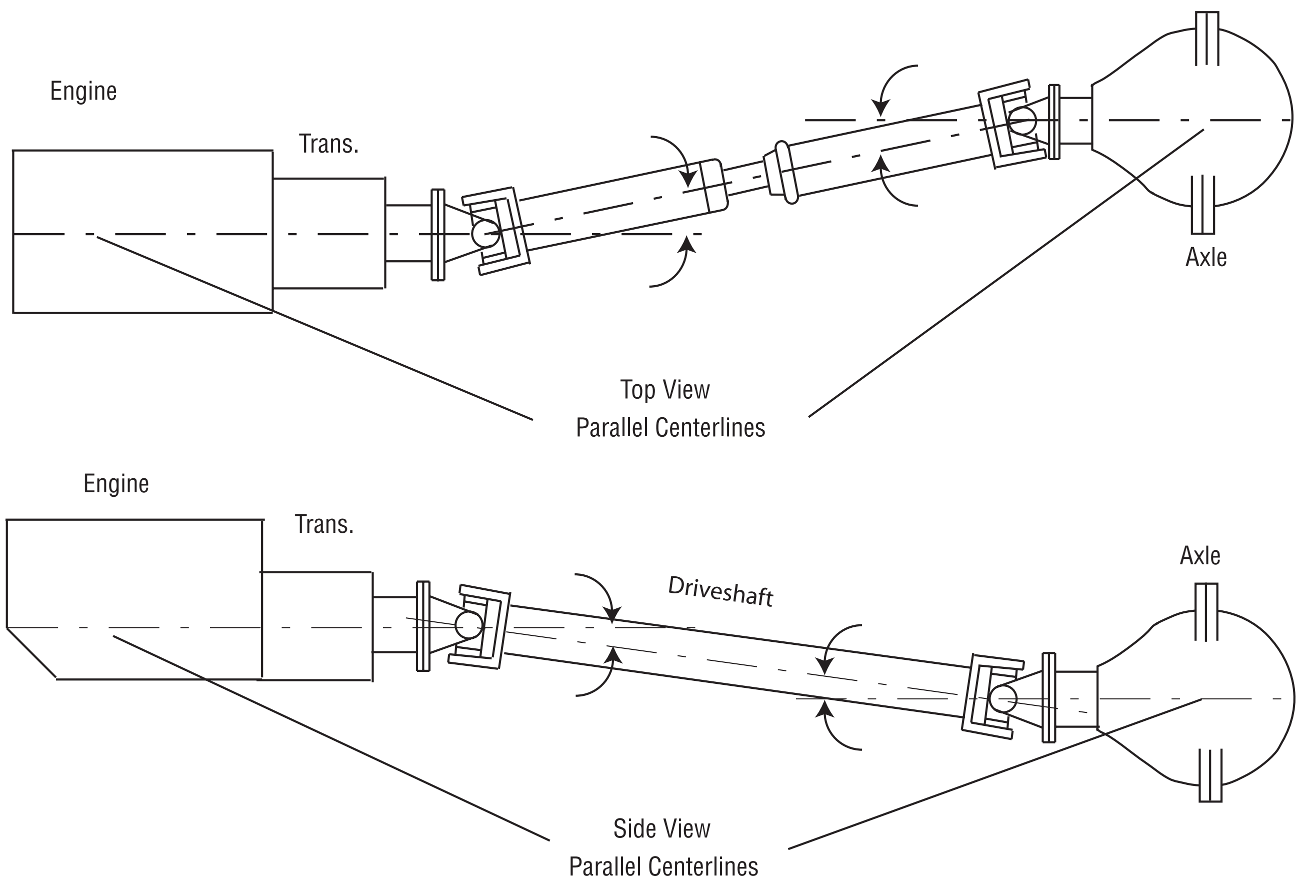


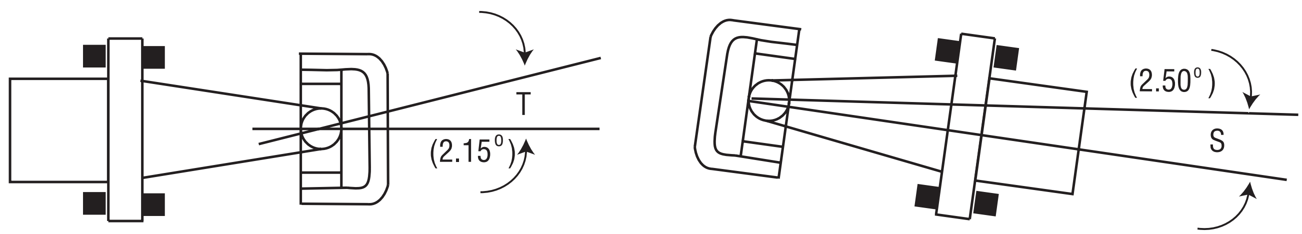
Figure 5

When you have a compound angle, you have to calculate the "True Universal Joint Operating Angle" of each universal joint. It is the True Universal Joint Operating Angle that must meet the three rules shown on page 5.

True Universal Joint Operating Angle

The True Universal Joint Operating Angle, which must be calculated for each end of the shaft with compound angles, is a combination of the universal joint operating angle in the top view, as determined from the chart, and the measured universal joint operating angle in the side view.

To determine the true universal joint operating angle for one end of a shaft, (compound angle C° in the formula shown in Fig. 6) insert the universal joint operating angle measurement obtained in the side view and the universal joint operating angle obtained from the chart into the formula.



Angle in Top View (from Chart) SideView

$$\text{Compound Angle } (C^\circ) = \sqrt{T^2 + S^2}$$

$T = 2.15^\circ$ (A calculated angle)

$S = 2.5^\circ$ (The measured angle)

$$C = \sqrt{2.15^2 + 2.5^2}$$

$$C = \sqrt{10.873}$$

$C = 3.3^\circ$ (True operating angle)

Figure 6

Do the same for the other end of the shaft. Compare the resultant calculated universal joint operating angle for each end. They should be EQUAL within 1 degree. If they're not, the driveshaft will vibrate.

Eliminating Compound Angle Induced Vibrations

Compound universal joint operating angles are one of the most common causes of driveline vibration. To avoid theses problems, remember these important points:

- When setting up an application that requires compound universal joint operating angles, always keep the centerlines of the transmission and axle parallel in both views.
- Always keep the offset between their horizontal and vertical centerlines small.

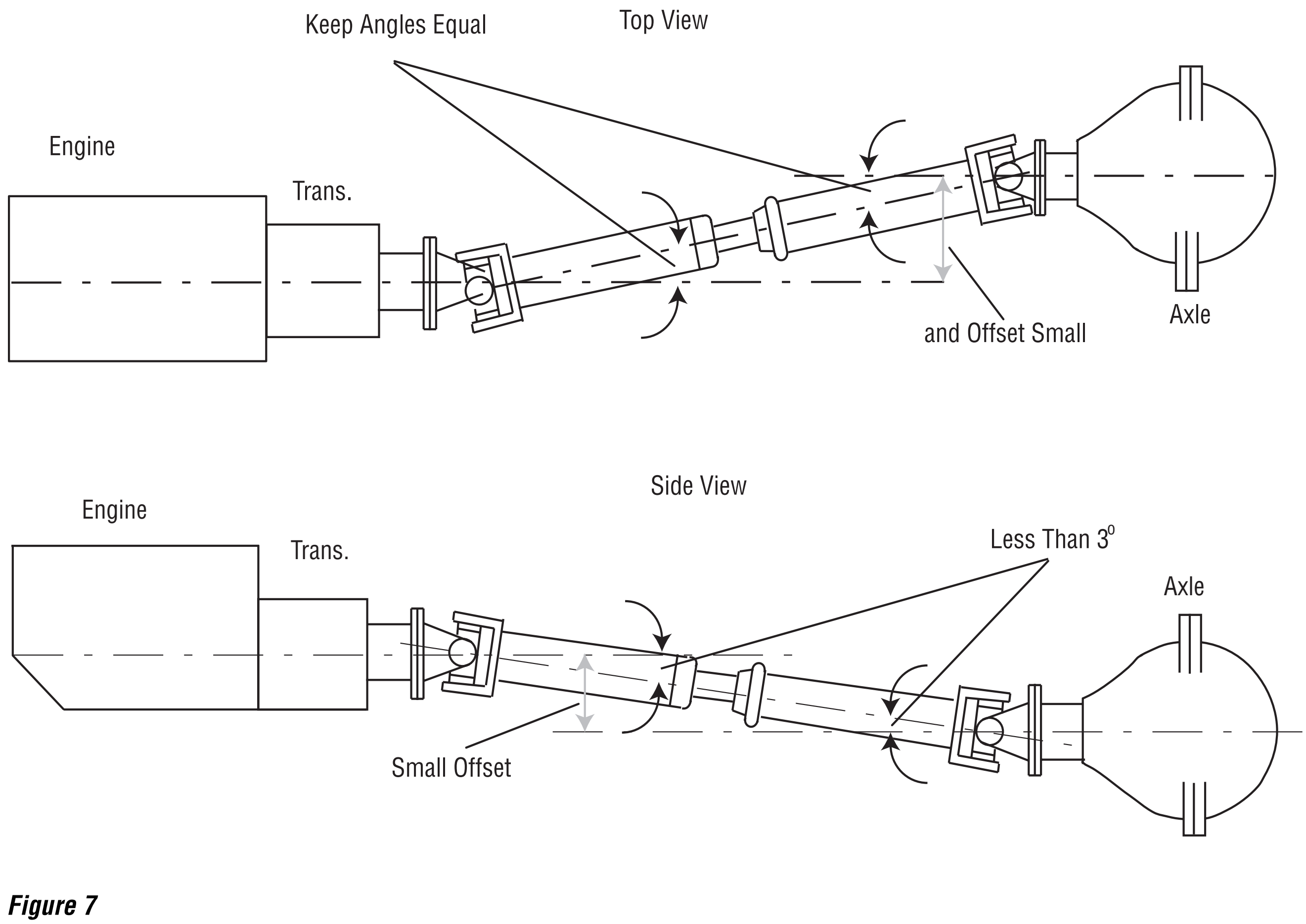


Figure 7

Note: Centerlines of transmission and axle must be parallel in both top and side views to use this method of determining true universal joint operating angle. Please contact Spicer Driveshaft Engineering if you have an application where the components cannot be installed with their centerlines parallel.

If adjustments must be made to the system:

- Install shims between the axle housing and springs to rotate the axle input yoke to change operating angles.
- Change operating angle on torque arm type suspensions by lengthening or shortening torque arms.
- Raise, lower, or shift side-to-side a pump, blower, or other piece of auxiliary equipment to change operating angles.

Note: It is important to remember to keep the centerlines of two components that are connected by a driveshaft parallel in both the top and side views, so the operating angles will ALWAYS be equal.

Angle Size

The magnitude of a vibration created by a universal joint operating angle is proportional to the size of the universal joint operating angle. Spicer Engineers recommend true universal joint operating angles of 3 degrees or less.

Obtain the true universal joint operating angle, as explained above, and if it is greater than 3 degrees, compare it to this chart.

Driveshaft RPM	Maximum Operating Angle	Interaxle	
		Parallel	Intersecting
5000	3.2°	-	-
4500	3.7°	-	-
4000	4.2°	3.8°	3.8°
3500	5.0°	4.4°	4.4°
3000	5.8°	5.1°	4.8°
2500	7.0°	6.0°	4.8°
2000	8.7°	6.0°	4.8°
1500	11.5°	6.0°	4.8°

The angles shown on this chart are the maximum universal joint operating angles recommended by Spicer Engineers and are directly related to the speed of the driveshaft. Any universal joint operating angle greater than 3 degrees will lower universal joint life and may cause a vibration. Remember to check maximum safe driveshaft RPM by using the Spicer Safe Operating Speed Calculator.

Multiple Shaft Installations

Multiple Shaft Set Up Recommendations

In general, multiple shaft installations follow the same guidelines, except there are different recommendations for setting up the driveline:

- For a 2-shaft application, set up the first coupling shaft (sometimes called a jackshaft) so that the universal joint operating angle that occurs at the transmission end is 1 to 1-1/2 degrees. (See Fig. 8)

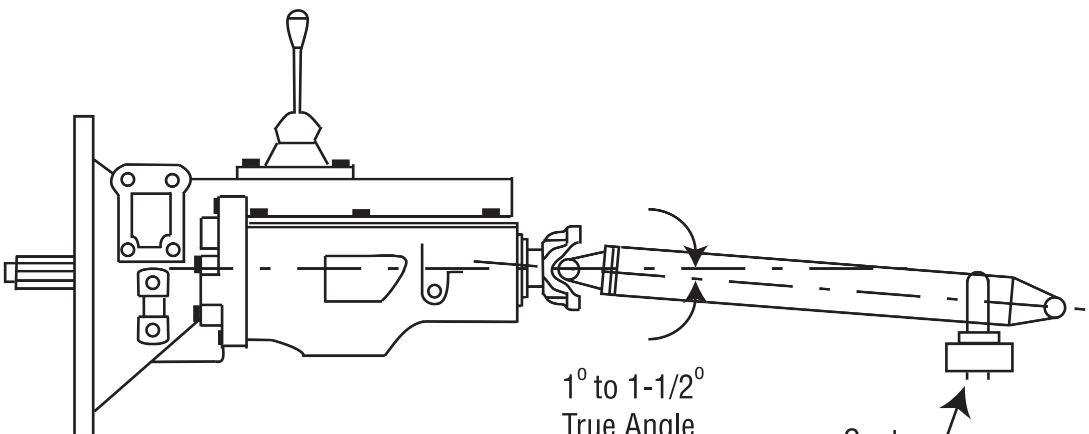


Figure 8

- Try to avoid building a compound universal joint operating angle into the first coupling shaft by installing it in line with the transmission.
- If it ends up being compound, make sure the true universal joint operating angle, determined by using the information mentioned earlier, is 1 to 1-1/2 degrees.

Install or tilt the axle so it is mounted on the same angle as the first coupling shaft (the centerlines of the axle and the first coupling shaft will be parallel).

Note: BY FOLLOWING THIS PROCEDURE, THE UNIVERSAL JOINT OPERATING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL. (See Fig. 9)

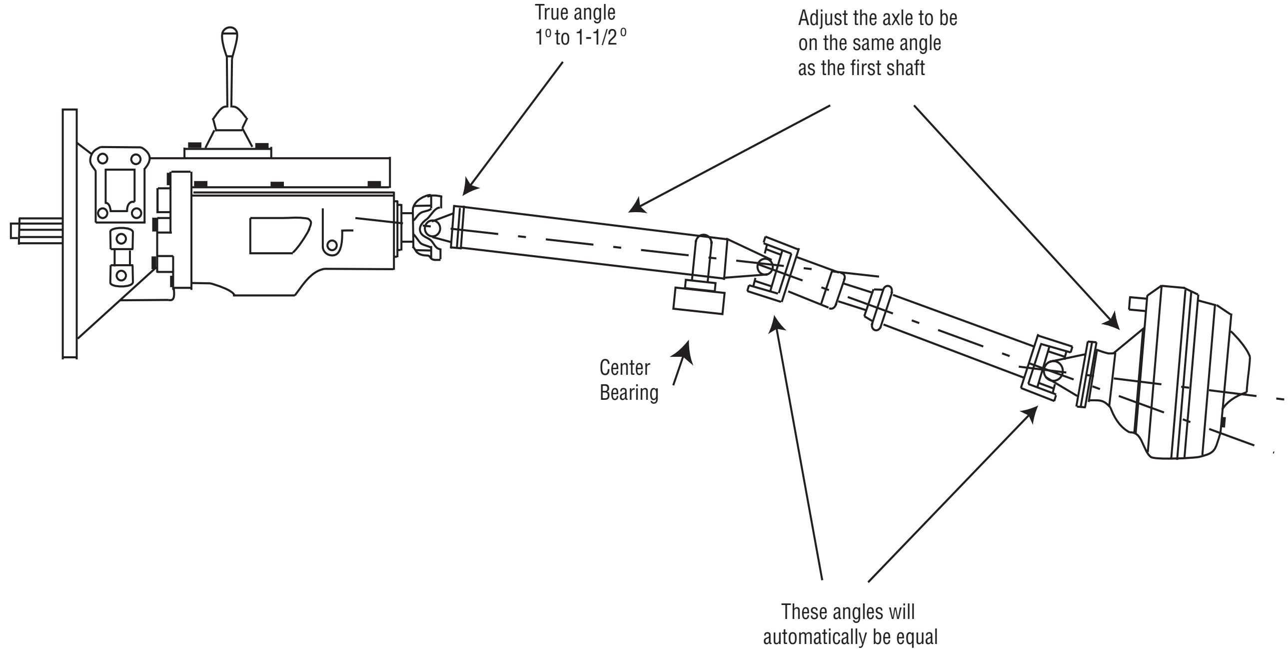


Figure 9

If there is an offset in the installation of the axle, make sure it does not create too large of a compound universal joint operating angle. Whenever possible, mount the axle directly in line with the first coupling shaft (when viewed from the top).

Check the actual universal joint operating angle at the rear of the first coupling shaft. If it is less than 1° and the transmission universal joint operating angle is greater than 1.5°, rotate the end yoke at the center bearing position so that the ears of the yoke are 90° to the ears of the tube yoke on the transmission end of the coupling shaft. (See Fig. 10) As an alternative, rotate the slip yoke on the driveshaft 90° if the slip spline has 16 teeth.

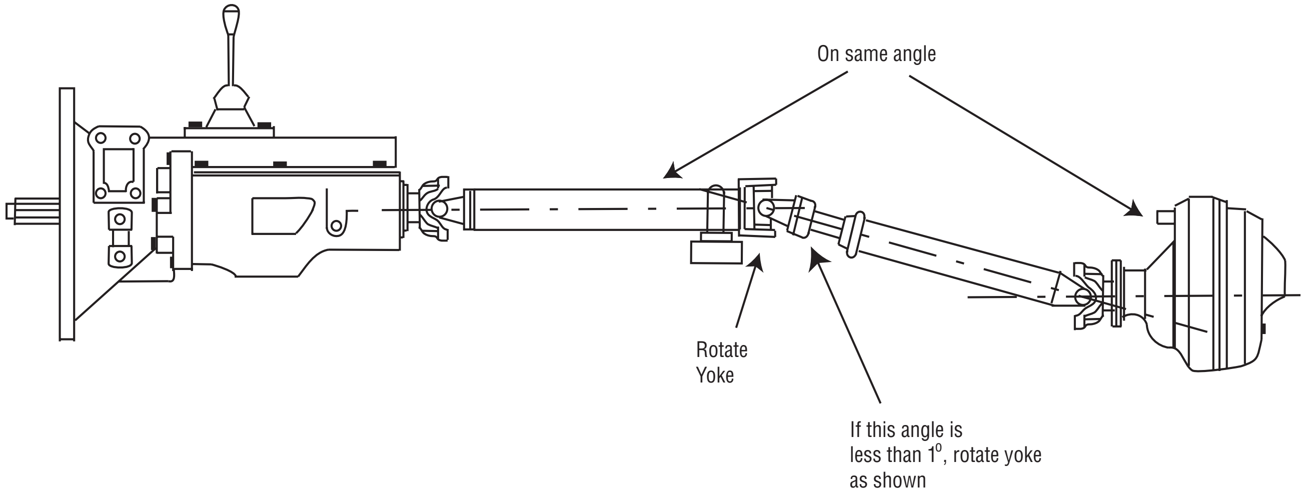


Figure 10

On applications having more than two shafts, mount the first coupling shaft as outlined in the preceding example, and each additional coupling shaft at a 1 to 1-1/2 degree universal joint operating angle to the previous coupling shaft.

Install or tilt the axle to the same angle as the last fixed coupling shaft so the centerline of the axle and the last fixed coupling shaft are parallel.

Note: THIS ASSURES THE UNIVERSAL JOINT OPEARTING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL (See Fig. 11).

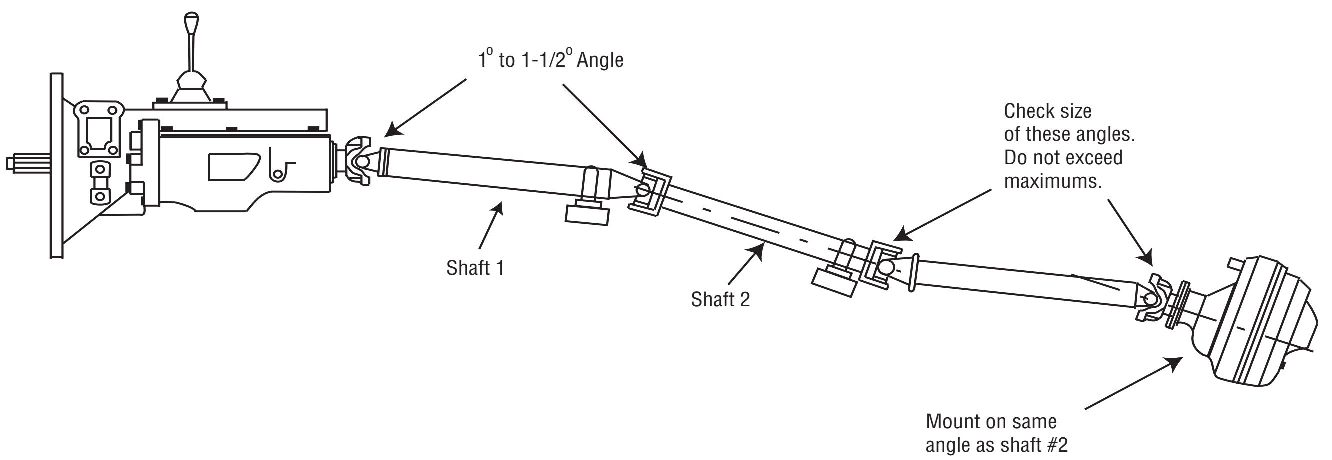


Figure 11

Mounting a Midship-Mounted PTO, Pump, or Auxiliary Transmission

When installing a midship-mounted PTO, auxiliary transmission, or midship-mounted pump into the main driveline of a vehicle, install it at the same angle as the transmission. Keep the offset to a minimum to reduce universal joint operating angles.

Note: Do not make the universal joint operating angle less than 1/2 degree.

Before bolting the device in place, check the universal joint operating angles that occur at each end of the driveshaft. They must be 1 to 1-1/2 degrees and they must be equal to within 1/2 degree for this type of application.

If the device ends up being installed in direct line with the transmission, with little or no universal joint operating angle on the joints, raise or lower it so there is enough offset to create the required 1 to 1-1/2 degree universal joint operating angle on each end of the driveshaft. (See Fig. 12)

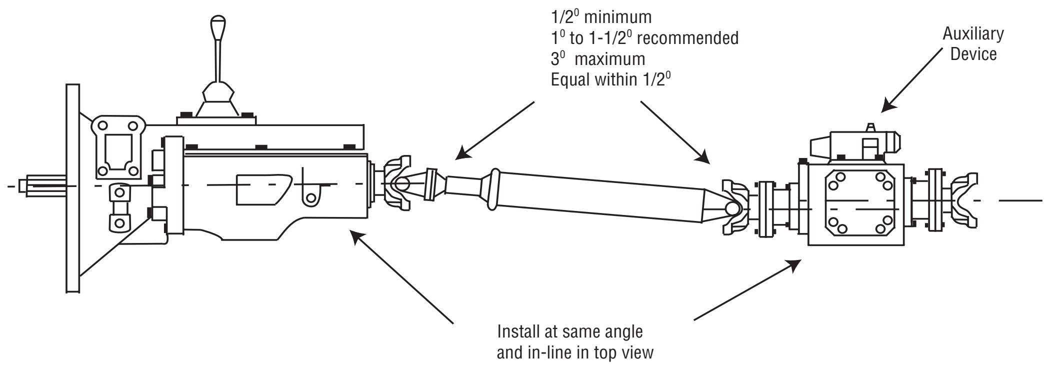


Figure 12

If there is only one driveshaft between the device and the rear axle, rotate the rear axle (using shims in the appropriate place) so it is the same angle as the device. This makes the universal joint operating angle at each end of the driveshaft equal (See Fig. 13). Check the size of the universal joint operating angles to determine if they meet recommendations.

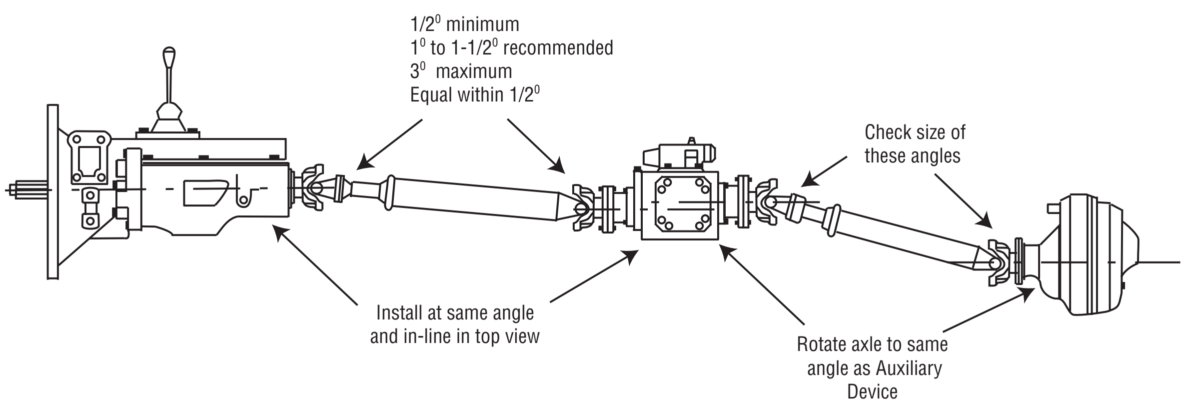


Figure 13

If there is more than one driveshaft between the device and the rear axle, install the driveshaft as outlined earlier with a 1 to 1-1/2 degree universal joint operating angle on the input end of each shaft. Then rotate the axle so it is on the same angle as the last fixed shaft. The universal joint operating angle on each end of the last shaft will automatically be equal. (See Fig. 14)

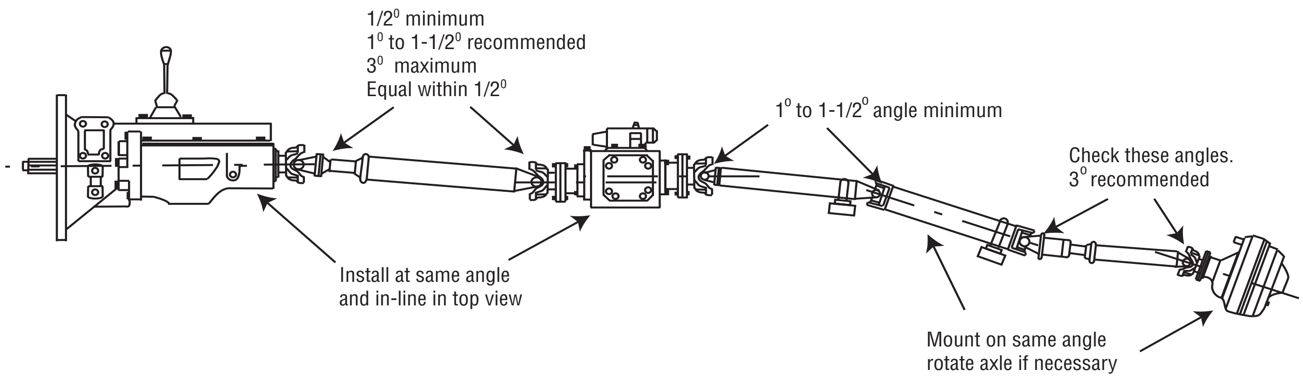


Figure 14

Mounting a Remote-Driven Pump, Blower, or Similar Device

Remote mounted-pumps, blowers, or similar devices are usually driven by a side, top, or bottom-mounted PTO and use an auxiliary driveshaft.

Many times these devices are mounted to the vehicle frame or cross member. The usual method of mounting, where the driven device is mounted parallel with the ground without regard to the mounted angle of the PTO, will produce a vibration that may cause failure of the PTO, pump, blower, or other driven device.

Any remote driven device must be mounted parallel and in line, if possible, with the PTO.

To select the appropriate auxiliary driveshaft for these types of applications, you should consider proper torque, safe operating speed (which is different than the critical speed for tubular driveshafts), and angularity. (See Maximum Safe Operating Speed Chart on page 18).

An auxiliary driveshaft must be capable of transmitting the maximum torque and RPM required by the driven equipment. For most low-torque applications operating at less than 1200 RPM, solid bar-stock constructed driveshafts are adequate. For applications requiring additional torque or RPMs, tubular shafts should be fabricated.

Maximum Safe Operating Speed

MAXIMUM OPERATING SPEED* BY TUBE SIZE, SOLID SHAFT SIZE, AND LENGTH *(For speeds over 6000 RPM, contact Spicer Universal Joint Division Engineering)											
TUBING	MAXIMUM INSTALLED LENGTH (IN INCHES) FOR GIVEN RPM										
Diameter & Wall Thickness W - Welded S - Seamless	Centerline to Centerline of Joints for a Two Joint Assembly or Centerline of Joint to Centerline of Center Bearing for a Joint and Shaft										
	RPM - Revolutions Per Minute										
	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
1.750" x .065" W	82"	67"	58"	52"	-	-	-	-	-	-	-
1.250" x .095" S	64"	52"	45"	40"	37"	34"	32"	-	-	-	-
2.500" x .083" W	87"	70"	62"	55"	50"	45"	43"	41"	39"	37"	35"
3.000" x .083" W	-	-	85"	76"	70"	64"	60"	57"	54"	51"	49"
SOLID SHAFT DIAMETER											
.750"	42"	35"	30"	27"	25"	-	-	-	-	-	-
.812"	44"	36"	31"	28"	26"	-	-	-	-	-	-
.875"	46"	37"	32"	29"	27"	-	-	-	-	-	-
1.000"	49"	40"	35"	31"	28"	-	-	-	-	-	-
1.250"	55"	45"	39"	35"	32"	-	-	-	-	-	-

To prevent premature wear, auxiliary driveshaft breakage, and possible injury to people or equipment, be aware of the critical speed of these types of driveshafts. Critical speed, explained earlier in this guide, is different for these solid shaft and small tube driveshafts.

Refer to the chart above for maximum safe operating speed information on these types of shafts.

If the chart indicates that the critical speed may be a problem, use multiple shafts. Be sure to use support bearings where necessary and set up the true universal joint operating angles as indicated earlier in this guide.

As with all driveshafts, auxiliary driveshafts should be:

- Carefully installed to minimize vibrations caused by incorrect universal joint operating angles
- Capable of absorbing shock loads
- Capable of changing length as needed
- Guarded so as to prevent inadvertent entanglement

Special Notes Regarding Auxiliary Driveshafts

WARNING: Working on or near an auxiliary driveshaft when the engine is running is extremely dangerous and should be avoided. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

- Shut off engine before working on power take-off or driven equipment.
- Do not go under the vehicle when the engine is running.
- Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.
- Fasteners should be properly selected and torqued to the manufacturer’s specifications.
- If a setscrew protrudes above the hub of an end yoke, you may want to replace it with a recessed (Allen-type) setscrew.
- If you decide that a recessed setscrew does not have enough holding power for your application and you must use a protruding setscrew, be sure no one can come in contact with the rotating driveshaft or the protruding setscrew.
- **Exposed rotating driveshafts must be guarded!**
- Lubricate auxiliary driveshafts according to manufacturer’s specifications.

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J3311-1-DSSP
8/08
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