(30)
PDR

TERRY CORPORATION

INFORMATION ONLY

THIS MANUAL HAS BEEN ASSEMBLED
FOR THE EQUIPMENT LISTED BELOW:

PURCHASER:	BYRON JACKSON PUMP DIVISION
ORDER NO:	V-147411 (R-1091N) DATE: 9-4-84
JOB NO:	
ULTIMATE USER:	CLEVELAND ELECTRIC/Toledo Edison
LOCATION:	DAVIS BESSE
SERVICE:	BJ PUMP Aux Feed Pump P14-2 WGR
ITEM NO'S:	
WORKS FILE NO:	WF-37686AB

Inlet Temp. 590°F **Exhaust Press.** 3 PSIG **Max. Steam** 1170 PSIG
Inlet Press. 885 PSIG **Exhaust Temp.** 243°F **Low Steam** 50 PSIG

TYPE Turbine	Gear	SERIAL NO: TURBINE	SERIAL NO: GEAR	ITEM NO:	BHP	KW	RPM
GS-2N		T-37686-A			800		3600
GS-2N		T-37686-B			800		3600

NOTICE

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New

BYRON JACKSON/TERRY TURBINE

12501-M-36AQ-8-1

THE TOLEDO EDISON COMPANY
NUCLEAR FACILITY ENGINEERING
DOCUMENT REVIEW

1. ☐ WORK MAY PROCEED.
2. ☒ REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO INCORPORATION OF CHANGES INDICATED.
3. ☐ REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
4. ☐ REVIEW NOT REQUIRED. WORK MAY PROCEED.

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BY: D.V. Wilczynski DATE: 10/15/84

ISSUE/REVISION

1 Issued for FCR 83-136 "Change-out of PG-PL gov. to PGG gov." Revision 2

CAUTION NOTICE

This turbine has been designed to provide safe and reliable service within the designed specifications. It is a pressure containing piece of rotating machinery; therefore, good judgement and proper safety practices to avoid damage to the equipment and surroundings and serious or painful injuries, must be exercised by responsible and qualified personnel.

The responsibility for correct operation, maintenance and training of personnel is that of the owner but, the following "DO NOT" and "DO" items are given.

DO NOT.. Use unauthorized parts or repairs. Use of parts, other than as manufactured or authorized for use by Terry or repairs performed by others not authorized by Terry to be so performed, will void any outstanding warranty on Terry equipment and will further relieve Terry of any liability for injury or damages resulting therefrom.

DO NOT.. Attempt to operate if installation is not correct and/or pre-operation (static) safety and control features have not been checked and verified.

DO NOT.. Attempt to operate until you have a thorough knowledge of the steam supply and exhaust system, its associated valves and drain system and the correct procedure for warming through and draining the system before starting the turbine.

DO NOT.. Attempt to operate until you have a thorough knowledge of the function and operation of the turbine control system, lubrication system, turbine drain and gland seal systems, safety devices and emergency operational procedures, mechanical and/or electrical.

DO NOT.. Attempt to operate, adjust, disassemble the turbine or its associated equipment until you have a thorough knowledge of the manufacturers instructions.

DO NOT.. Wear neckties or loose clothing when standing near couplings or any rotating parts.

DO NOT.. Remove any inspection covers or guards when the unit is it operation.

DO NOT.. Open up bearings, oil reservoirs or lube system until is sufficiently cooled.

CAUTION NOTICES CONTINUED....

DO NOT.. Use the turbine casing eye bolt for lifting the turbine. Rig suitable slings for lifting.

DO NOT.. Attempt repairs of a questionable nature.

DO...... Consult the manufacturer should any problems arise or are foreseeable.

DO...... After starting, test and verify the correct function of the overspeed device (mechanical/electrical) before putting the unit into service. Refer to the manufacturers instructions for the correct procedure.

DO...... After starting and verification of overspeed device, test and verify the correct function of the governor or control system through its range before putting unit into service.

DO...... After starting, check and verify that the lubrication system has sufficient oil and is operating satisfactorily.

DO...... Avoid personal contact with the turbine casing, valve bodies, drains and steam lines. Serious burns may result. Wear protective clothing and develop safety awareness.

DO...... Ensure that the lifting devices used have been regularly tested and have a sufficient safety factor for the weight to be lifted. Also ensure that lifting devices are properly secured before any lifting is done.

DO...... Ensure all steam and exhaust lines are completely drained and isolated and all turbine drains open before attempting to work on the turbine.

DO...... Fit spades, blinds or blank flanges of sufficient design to withstand full line steam pressure in the inlet and exhaust lines if the turbine is to be dismantled.

DO...... Protect against possible head and hearing injury by wearing the application protective equipment.

SECTION 1 - INTRODUCTION

This instruction manual has been prepared for the equipment described on the title page and is intended as an aid to supplement the experience and ability of qualified personnel in the installation, operation and maintenance of rotating equipment and its associated auxiliaries and controls.

The instructions contained in this manual do not purport to cover all details nor provide for every possible contingency to be met in connection with installation, operation or maintenance.

The supplying of instructions does not imply in any manner or to be construed that, the Terry Corporation accepts liability for work carried out by a customer or contractors personnel. Liability is limited to and as stated in our warranty.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to The Terry Steam Turbine Company.

Please address any inquiries to the attention of the Service Manager, The Terry Corporation, P.O. Box 555, Windsor, Connecticut 06095.

Consultation: Our Engineering Department welcomes inquiries regarding any phase of steam turbine practice, installation, operation or design changes to meet special conditions.

Inspection: Your TERRY equipment can be expected to operate successfully for years without much special attention; however, periodic inspection of vital parts can greatly help in avoiding unscheduled shutdowns.

If you will write us fully about any trouble or unusual wear, we will be pleased to offer our help in their solution.

Service: We maintain a force of trained engineers and service representatives, skilled in turbine work, who are available for installation, inspection or overhaul of TERRY equipment. They can be secured on reasonable notice. A charge at a daily or hourly rate while away from our Plants, plus expenses, with an extra charge for overtime, is made for their services. We will be glad to supply you with our current rates for these services.

The proper erection and starting of any turbine or gear is highly important. The success of a unit frequently hinges on how it is installed. We strongly urge that such work be supervised by skilled personnel thoroughly familiar with steam turbine work. Unless you have men available with proper experience and ability, it would be advisable to employ our service representatives. These men can instruct the operators in the care and handling of the units.

Many companies, especially those operating several TERRY units have our service representatives make periodic inspection to forestall trouble and to insure that best possible results. Our personnel can explain how to operate TERRY equipment to secure the greatest usefulness and economy, and the longest life.

When requesting for the services of a service representative or an engineer, be sure to give us the equipment serial number with full particulars as to what new parts are, or may be, needed. This will enable us to instruct our personnel for the work required. If possible, have these parts on hand.

If the trouble involves apparatus other than that of Terry manufacture, such as generators, pumps, blowers, governors, etc., we recommend that any such work be done by the manufacturer of this equipment. Our personnel are instructed that they must secure authorization from our factory before under-taking work on any apparatus not manufactured by us.

Shipment: After final completion of test and inspection the oil is drained from the unit and the reservoir and sumps are cleaned. All exterior machined and exposed surfaces are coated with a rust preventative. The interior of the turbine is sprayed through all available openings with a suitable rust preventative. All tapped pipe connections are plugged and flanged pipe connections are covered with wood or metal enclosures and all exterior parts of the unit coated with shop paints or such paints and procedures specified by the buyer.

Turbines and gears are shipped mounted on skids and enclosed in open frame work crating as required by the transporation company for domestic shipments. When boxed for export, the unit is packed in a totally enclosed box.

Receiving Shipment: Immediately upon receipt of shipment, check the items received against those shown on the packing list.

Care should be used when opening up a crate for inspection and checking for damage and shortage. Check the bottom of the crate because some parts, such as loose piping, trip and throttle valve, coupling halves, coupling guards, are attached to the bottom of the crate.

Any claims for shortages or damages suffered in transit shall be submitted by the receiver directly to the carrier and a copy of the report forwarded to The Terry Steam Turbine Company within ten (10) days after receipt.

Storage: On completion of receiving inspection, action must be taken to protect the equipment if it is not to be installed immediately. The unit should be kept in its crate and attached to the skid until ready to install on its foundation.

The equipment should at all times be stored in a clean, non-corrosive atmosphere and protected against loss, weather, damage and foreign materials such as dust, sand, etc.

Indoor storage where constant temperature is maintained at a level which will prevent condensation is preferred. Should preparation for additional protection be required for adverse conditions or for an extended period of time it is recommended that The Terry Steam Turbine Company be consulted.

For outdoor storage or in areas with a corrosive atmosphere, additional protection is usually necessary.

The standard preservation procedure applied by Terry is for 18 (eighteen) months under indoor storage conditions.

NOTE:

The purchaser shall be responsible for all expenses related to returning the unit to original factory condition including the services of a Terry engineer or service representative.

WARRANTY

Our Standard Warranty Clause is as follows:

"The Company warrants that the equipment manufactured by it and delivered hereunder will be free of defects in material and workmanship for a period of twelve months from the date of placing the equipment in operation or eighteen months from the date of shipment, whichever shall first occur. Should any failure to conform to this Warranty be reported in writing to the Company within said period, the Company shall, as its option, correct such nonconformity, by suitable repair to such equipment or, furnish a replcement part F.O.B. point of shipment, provided the Purchaser has stored, installed, maintained and operated such equipment in accordance with good industry practices and has complied with specific recommendations of the Company. Accessories or equipment furnished by the Company, but manufactured by others, shall carry whatever warranty the manufacturers have conveyed to the Company and which can be passed on to the Purchaser. The Company shall not be liable for any repairs, replacements, or adjustments to the equipment or any costs of labor performed by the Purchaser or others without the Company's prior written approval.

The effects of corrosion, erosion an normal wear and tear are specifically excluded from the Company's Warranty. Performance warranties are limited to those specifically stated within the Company's proposal. Unless responsibility for meeting such performance warranties are limited to specified shop or field tests, the Company's obiligation shall be to correct in the manner and for the period of time provided above.

THE COMPANY MAKES NOT OTHER WARRANTLY OR REPRESENTATION OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES, INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

Correction by the Company of nonconformities whether patent or latent, in the manner and for the period of time provided above, shall constitute fullfillment of all liabilities of the Company for such nonformities, whether based on contract, warranty, negligence, indemnity, strict liability or otherwise with respect to or arising out of such equipment."

The rights and obiligations of Purchaser and Company shall be governed by the laws of the State of Connecticut.

GITD REV. 2/84

TERRY TURBINE DATA SHEET

OPERATING CONDITIONS

	HP	KW	RPM	STEAM RATE LB/HP/HR	STEAM RATE LB/KW/HR	OPERATING SPEED RANGE R.P.M.
RATED	800		3600	41.0		1100-3710
NORMAL						
PART LOAD						
OVERLOAD						
LOW STEAM						

1st CRITICAL SPEED ________ RPM 2nd CRITICAL SPEED ________ RPM TRIP SPEED 4500 RPM

STEAM/~~GAS~~ CONDITIONS

INLET STEAM/~~GAS~~ NORM 885 PSIG 590°FTT. MAX. INIT. 1170 PSIG 600°FTT MIN. INIT. 50 PSIG 281°FTT

EXHAUST STEAM NORM 3 PSIG/~~VAC~~ 243°FTT

STEAM RATE GUARANTEE POINT, HP/~~KW~~ 800 STEAM 885 PSIG, EXH 243°FTT LB (HP/~~KW~~) HR 41

FULL LOAD EXHAUST TEMP 243°FTT. MAX. CASING PRESS 165 PSIG. SENTINEL RELIEF VALVE SETTING 30 PSIG

TURBINE CONNECTIONS

	SIZE	RATING	FLANGE FACE	POSITION
INLET	4"	900# ASA	RF	RH FACING COUPLING
EXHAUST	8"	300# ASA	FF	LH FACING COUPLING

TOLEDO EDISON COMMENT

CONSTRUCTION FEATURES

FRAME DESIGNATION TYPE	GS-2N
CASING SPLIT	HORIZONTAL
STEAM FLOW	HELICAL-SOLID
NO. OF WHEELS	1
STAGES	N/A
BLADES	N/A
ROTOR CONST.	BUILT UP
STEAM CHEST	N/A
STEAM RING	YES
JETS	YES
NOZZLE BLOCK	N/A
REV. CHAMBERS	YES
RATEAU	N/A
INTERSTAGE SEALS	N/A
END GLAND SEALS	CARBON
GLAND SEAL SYSTEM	PRESS. LEAKOFF

HORIZONTAL ☒ VERTICAL ☐

JETS/~~NOZZLE GROUP~~ POSITIONS	1 Through 10
NO. JETS/~~NOZZLES~~	10
DIAMETERS	.480
NO. NOZZLE GROUPS	N/A
NO. IN EACH GROUP	N/A
HAND VALVES	N/A
H.V. POSITIONS	N/A
ROTATION FACING COUPLING	COUNTERCLOCKWISE
CASING SUPPORT	FOOT
BEARINGS (ROTOR) RADIAL TYPE	SLEEVE; THRUST: BALL
LUBRICATION	RING; FROM: TURBINE
OVERSPEED TRIP	MECH. DISC; TRIP VALVE: T&T
T&T VALVE	HYD. MANUAL; TRIP: MECH. MANUAL; MANUF: GIMPEL

NOTE: JETS, HAND VALVES & NOZZLE GROUP POSITIONS ARE NUMBERED IN A CLOCKWISE DIRECTION STARTING JUST BELOW THE CASING HORIZONTAL JOINT AT THE RIGHT HAND SIDE WHEN FACING THE STEAM RING OR STEAM CHEST FROM THE TURBINE HIGH PRESSURE END

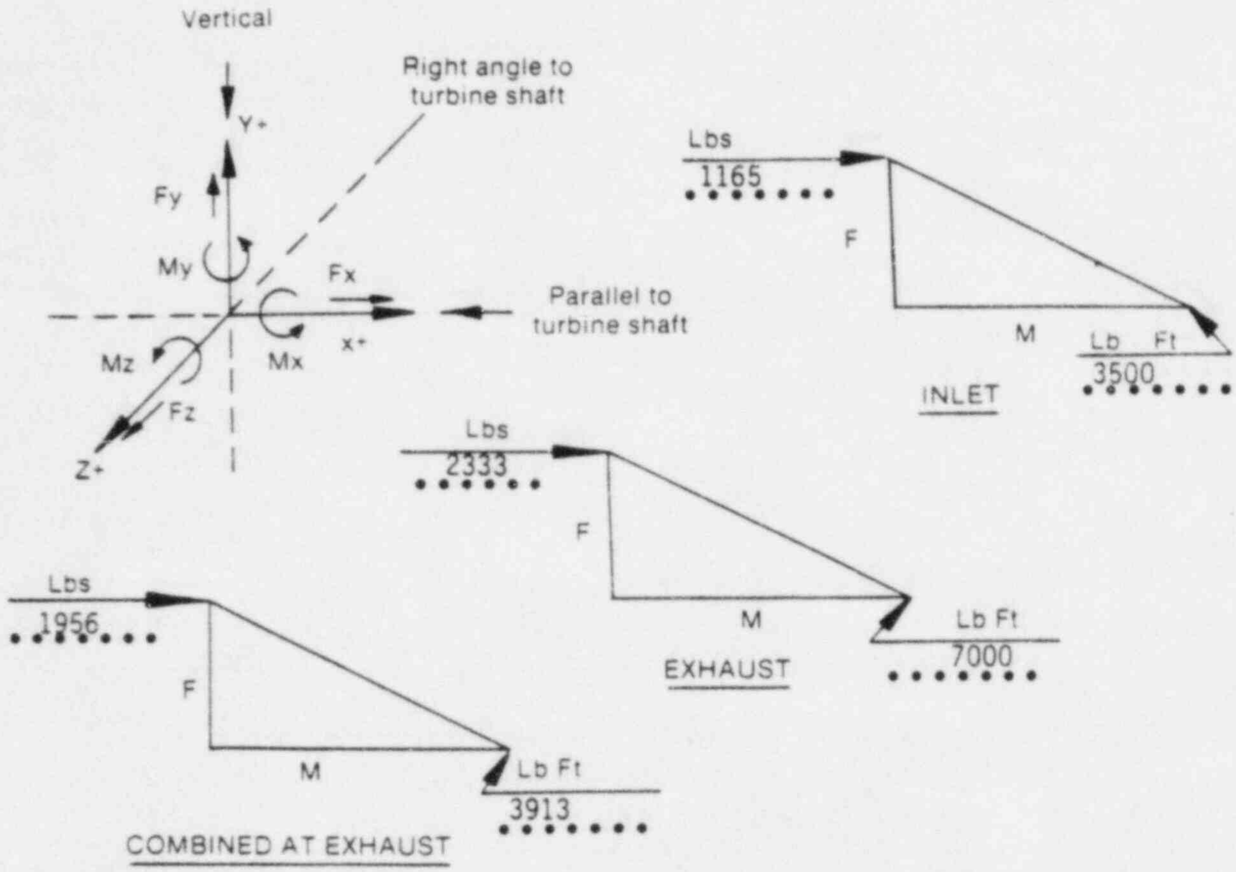
GOVERNOR TYPE	MECH. HYD.
GOVERNOR VALVES	SINGLE
ACTUATION	DIRECT
GOVERNOR MANUF.	WOODWARD
MODEL	PGG
NEMA CLASS	D

COUPLING SUPPLIED BY	OTHERS
COUPLING TYPE	OTHERS
BASE TYPE	OTHERS
BASE LOCATION	OTHER
OUTLINE NUMBER	78748D

TURBINE NO. T-37686 AB

TERRY STEAM TURBINE CO.
LAMBERTON ROAD • WINDSOR CONNECTICUT U.S.A.

Allowable Forces and Moments—Nema Standards



Max. Combined Forces & Moments at Exhaust

- Fx = 782, Fy = 1956, Fz = 1564, When M = O
- Mx = 3913, My = 1956, Mz = 1956, When F = O

Allowed Forces (F) & Moments (M)
Ref: NEMA Std. Pubn. No. SM 23-1979. Sect. 8.06

Inlet: 4" In, Exhaust: 8" In, Turbine Type: GS-2N Serial No: T- 37686AB

W0224
R1980

Prepared by: Richard S. Golas Date: 9-4-84

SIZE-IN		INLET		EXHAUST		COMBINED AT ℄ OF EXHAUST							
INLET	EXHAUST	F_{max}	M_{max}	F_{max}	M_{max}	F_{max}	M_{max}	F_x	F_y	F_z	M_x	M_y	M_z
2	4	333	1000	666	2000	559	1118	224	559	447	1118	559	559
	6	333	1000	1000	3000	791	1581	316	791	632	1581	791	791
	8	333	1000	1333	4000	1031	2062	412	1031	825	2062	1031	1031
	10	333	1000	1444	4333	1175	2350	470	1175	940	2350	1175	1175
	12	333	1000	1555	4667	1257	2514	503	1257	1006	2514	1257	1257
	14	333	1000	1666	5000	1339	2679	536	1339	1071	2679	1339	1339
	18	333	1000	1889	5667	1504	3009	602	1505	1204	3009	1505	1505
	20	333	1000	2000	6000	1587	3175	635	1587	1270	3175	1587	1587
	24	333	1000	2222	6667	1753	3507	701	1753	1403	3507	1753	1753
	30	333	1000	2555	7667	2003	4006	801	2003	1602	4006	2003	2003
	36	333	1000	2889	8667	2252	4505	901	2252	1802	4505	2252	2252
3	4	500	1500	666	2000	625	1250	250	625	500	1250	625	625
	6	500	1500	1000	3000	838	1677	335	839	671	1677	839	839
	8	500	1500	1333	4000	1068	2136	427	1068	854	2136	1068	1068
	10	500	1500	1444	4333	1185	2370	474	1185	948	2370	1185	1185
	12	500	1500	1555	4667	1265	2531	506	1265	1012	2531	1265	1265
	14	500	1500	1666	5000	1346	2693	539	1347	1077	2693	1347	1347
	18	500	1500	1889	5667	1510	3021	604	1510	1208	3021	1510	1510
	20	500	1500	2000	6000	1592	3185	637	1593	1274	3185	1593	1593
	24	500	1500	2222	6667	1758	3516	703	1758	1406	3516	1758	1758
	30	500	1500	2555	7667	2006	4012	802	2006	1605	4012	2006	2006
	36	500	1500	2889	8667	2225	4510	902	2255	1804	4510	2255	2255
4	6	666	2000	1000	3000	901	1803	361	901	721	1803	901	901
	8	666	2000	1333	4000	1118	2236	447	1118	894	2236	1118	1118
	10	666	2000	1444	4333	1199	2398	480	1199	959	2398	1199	1199
	12	666	2000	1555	4667	1277	2554	511	1277	1022	2554	1277	1277
	14	666	2000	1666	5000	1356	2713	543	1357	1085	2713	1357	1357
	18	666	2000	1889	5667	1518	3037	607	1518	1215	3037	1518	1518
	20	666	2000	2000	6000	1600	3200	640	1600	1280	3200	1600	1600
	24	666	2000	2222	6667	1764	3528	706	1764	1411	3528	1764	1764
	30	666	2000	2555	7667	2011	4022	804	2011	1609	4022	2011	2011
	36	666	2000	2889	8667	2259	4518	904	2259	1807	4518	2259	2259
6	8	1000	3000	1333	4000	1166	2333	467	1167	933	2333	1167	1167
	10	1000	3000	1444	4333	1236	2472	494	1236	989	2472	1236	1236
	12	1000	3000	1555	4667	1309	2618	524	1309	1047	2618	1309	1309
	14	1000	3000	1666	5000	1384	2769	554	1385	1108	2769	1385	1385
	18	1000	3000	1889	5667	1540	3081	616	1541	1232	3081	1541	1541
	20	1000	3000	2000	6000	1620	3240	648	1620	1296	3240	1620	1620
	24	1000	3000	2222	6667	1781	3562	712	1781	1425	3562	1781	1781
	30	1000	3000	2555	7667	2025	4050	810	2025	1620	4050	2025	2025
	36	1000	3000	2889	8667	2270	4541	908	2271	1817	4541	2271	2271
8	10	[illegible]	4000	1444	4333	1288	2576	513	1284	1027	2567	1284	1284
	12	[illegible]	4000	1555	4667	1351	2702	540	1351	1081	2702	1351	1351
	14	[illegible]	4000	1666	5000	1422	2844	569	1422	1138	2844	1422	1422
	18	[illegible]	4000	1889	5667	1571	3142	628	1571	1257	3142	1571	1571
	20	[illegible]	4000	2000	6000	1647	3295	659	1648	1318	3295	1648	1648
	24	[illegible]	4000	2222	6667	1804	3608	722	1804	1443	3608	1804	1804
	30	[illegible]	4000	2555	7667	2043	4087	818	2044	1635	4087	2044	2044
	36	1333	4000	2889	8667	2286	4573	915	2287	1829	4573	2287	2287
10	12	1444	4333	1555	4667	1401	2802	560	1401	1121	2802	1401	1401
	14	1444	4333	1666	5000	1467	2934	587	1467	1174	2934	1467	1467
	18	1444	4333	1889	5667	1608	3216	643	1608	1286	3216	1608	1608
	20	1444	4333	2000	6000	1682	3364	673	1682	1345	3364	1682	1682
	24	1444	4333	2333	7000	1910	3821	764	1911	1529	3821	1911	1911
	30	1444	4333	2555	7667	2067	4135	827	2068	1654	4135	2068	2068
	36	1444	4333	2889	8667	2307	4614	923	2307	1845	4614	2307	2307

NOTE: ALL FORCES ARE GIVEN IN LBS.
ALL MOMENTS ARE GIVEN IN FT-LB.

GOVERNOR SETTING WITH WOODWARD GOVERNOR - CAM OPERATED

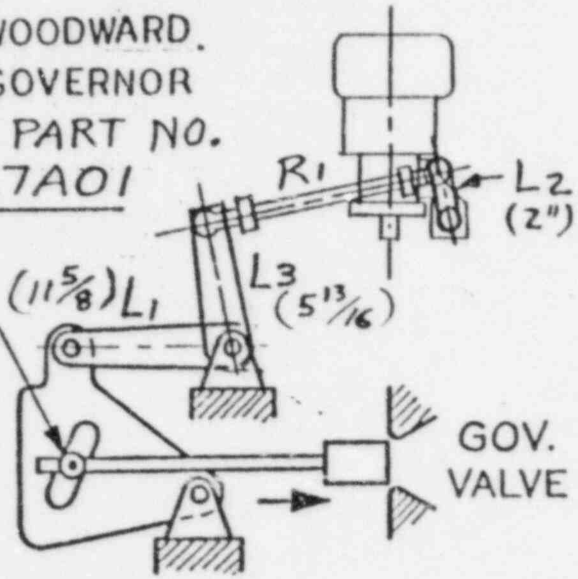
TURBINE NO. R1091N TYPE GS-2N FILE 37686AB H.P. 800 R.P.M. 3600

VALVE SIZE 3" VENTURI	DRIVE GEAR RATIO 3:1	EMERG. TRIP SPEED 4500

HIGH SPEED STOP SET AT 3710 TURB. RPM & 1236.7 GOV. RPM

TERMINAL SHAFT. TOTAL AVAILABLE ANGULAR TRAVEL 30° EFFECTIVE ANGULAR TRAVEL 21°-36'
APPROX VALVE TRAVEL . 5/8

PGG WOODWARD. GOVERNOR
TERRY PART NO. 128727A01



	CALCULATED VALVE OPENING	TURB. R.P.M.	AIR PRESS.	WOODWARD GOV. R.P.M.
MAX. OPER.	5/8	3710	—	1236.7
NORMAL HIGH		3600	—	1200
NORMAL LOW.		1100	—	366.7

1. WITH VALVE 5/16 OPEN, SET LEVER L1 HORIZONTAL. CAM PLATE SHOULD BE IN MID-POSITION.
2. WITH VALVE CLOSED, ADJUST CAM ROLLER ON STEM SO THAT IT IS JUST 1/16" OFF OF BOTTOM STOP.
3. ADJUST CONNECTING ROD R1 SO THAT TERMINAL SHAFT LEVER L2 IS IN MID-STROKE POSITION AND IS PARALLEL TO GOV. VALVE LEVER L3

NOTES:

GOV. LEVER LAYOUT L-2982

LEVER DIAGRAM

FIGURED BY DWT 4-16-84
CHECKED BY A.P.

F37686AB
R-1091N MF4

THE TERRY STEAM TURBINE CO.

SECTION 2 - TECHNICAL DATA

Recommended Turbine Steam Joint Compounds

1. The following sealing materials are recommended for use within the temperature limits and turbine areas specified:

2. Applicable Turbine Joint Areas

   - Case horizontal joint
   - Case vertical joints
   - Steam ring or steam chest joint to case horizontal or vertical joint, as applicable
   - Gland case to turbine case joint (s)
   - Steam chest cover to steam chest joint
   - Nozzle block to steam chest joint (s)

3. Sealing Materials and Limits

   All turbine bolted joints which require use of a sealant material to ensure a leakproof joint shall employ the following sealants for flanges exposed to the temperatures listed. Temperatures to be based on inlet steam conditions for the entire flange. The following sealing materials shall be utilized for "RIGID FLANGE DESIGNS":

   - RTV 732 Black: Below 500^{o}F (260^{o}c)
   - Turbo "R": 500^{o}F (260^{o}c) to 750^{o}F (399^{o}c), inclusive
   - Alinco: Above 750^{o}F (399^{o}c)

   FLEXIBLE FLANGE DESIGNS shall use the following:

   - RTV 732 Black: Below 500^{o}F (260^{o}c)
   - TEMP-TITE String Kit: 500^{o}F (260^{o}c) and above

   SPECIAL CUSTOMER MANDATE: Shall include applications where customer requirements dictate the use of ALINCO (triple boiled linseed oil).

   NOTE: THIS SEALANT MUST BE HEAT CURED AFTER ASSEMBLY.

   TYPE GS NUCLEAR TURBINES: On case horizontal joint and on gland case joints to turbine case shall utilize the following:

   - TEMP-TITE STRING KIT ONLY

FIELD CHANGES: Should repair and/or maintenance become necessary, the following sealing materials shall be substituted for all field units where string-type casing steam joints were previously used:

- TEMP-TITE STRING KIT: String Gasket in Turbo Seal 50

4. Turbine Component Joints (Other Than Case)

COPALITITE: Shall be used, unless otherwise specified, for components which shall include, but may not be limited to the following:

- Steam ring or steam chest plug (s)
- Jet bodies and/or dummy jet bodies
- L - Gland stem packing bonnet
- Hand valve bonnet (s), body (bodies)
- Nozzle block (s) using asbestos gasket
- Valve cage (after lapping to valve body)

NOTE: Copaltite shall not be used for main case joints covered in "Applicable Turbine Joint Areas".

5. Lube Oil Joints

Horizontal split and vertical flange of bearing housing, if applicable, shall utilize the following sealing material:

- PERMATEX #2

6. Procedure and Materials

6.1 RTV 732 Black (Manufactured by Dow Corning Corp., Midland, MI 48640)
(Shelf life: 1 year)
- Apply a continuous bead (s) to sealing surface. Assemble joint. No special precautions for cure are required - assembled unit is suitable for steam service in four (4) hours. Assembly with this sealant must proceed as quickly as possible before the sealant cures and forms a rubber gasket.

6.2 Turbo "R" - (Manufactured by Industrial Gasket and Shim Co., Inc., P.O. Box 368, Meadow Lands, PA 15347) - (Shelf life of 1 year - UNUSED MATERIAL MUST BE KEPT TIGHTLY COVERED!).

- Apply uniformly on sealing surface to cover with a minimum layer of sealant. Spray Turbo "R" film with chemical catalyst (2 percent solution) furnished. A fine, uniform spray which completely wets exposed sealant is required. Assemble joint.

- Curing time used is 24 hours at room temperature. If necessary turbine may be subjected to steam service after 4 hours provided elevated temperature is present at low steam pressures.

- If "catalyst" is not available, cure may be promoted by application of heat. Flange (s) must be held at a temperature of 300°F. (149°c), minimum, for a period of one hour. During cure, internal pressure must be as practicable. (NOTE: Saturation pressure for 300°F. (149°c.) is 65 PSIG).

6.3 Temp-Tite String Kit - String Gasket in Turbo Seal 50 - (Manufactured by Industrial Gasket and Shim Co., 200 Country Club Road, P.O. Box 368, Meadow Lands, PA 15347) - (Shelf life of 6 months - UNUSED MATERIAL MUST BE KEPT TIGHTLY COVERED!).

- Place a continuous run of Temp-Tite string on sealing surface using Turbo "R" as an adhesive. Assemble joint. No special precautions for cure are required - assembled unit is suitable for immediate steam service.

6.4 Wheeler's Alinco Compound - (Triple boiled linseed oil - Manufactured by Wheeler's Paint Inc., 502 East Ohio Street, Pittsburg, PA 15212 - may be available from "industrial suppliers").

- This sealant must be heat cured after assembly!

- Apply uniformly on sealing surface to cover with minimum layer of sealant. Assemble joint.

- Cure must be accomplished by heating flange (s) to approximately 400°F. (204°c.) and held at this temperature for 2 hours. During cure, internal pressure must be as low as practical. Some insulation is advisable to minimize heat loss during curing. Flange temperature should be monitored by thermocouple pyrometer, or other suitable method.

6.5 Copaltite - (Manufactured by National Engineering Products, Inc., 15th and New York Avenues, N.W., Washington, D.C. 20005).

- Apply a thin, uniform layer to cover sealing surfaces. Assemble joint. No special precautions for cure are required - assembled unit is suitable for steam service in 4 hours.

6.6 Permatex #2 - (Manufactured by Permatex Co., Inc., 2300 N. Florida Mango Road, P.O. Box 1350, W. Palm Beach, Florida 33401 - may be available only from "industrial suppliers").

- Apply with fingers. Do not exceed a thickness of 0.015" (0.4 mm) when applying.

IMPORTANT NOTICE

FOR UNITS WITH BASEPLATES

READ CAREFULLY BEFORE GROUTING

This unit has been carefully aligned and doweled at the factory prior to shipment.

All baseplates deflect to some extent; therefore, original alignment must be reestablished BEFORE unit is grouted in.

Before grouting and with steam lines disconnected, proceed as follows:

1. Mount unit on foundation and support base on several metal wedges or blocks well distributed around edge of baseplate. Allow 0.5 to 1 inch between base and foundation for grouting.

2. Check alignment. If incorrect, reestablish original alignment by shimming the blocks or adjusting the wedges until correct alignment is obtained. No redoweling is necessary.

Since a baseplate will spring unless rigidly supported, grouting must be done carefully and base completely filled with grout to maintain permanent alignment.

INSTALLATION

1. FOUNDATION

1.1 The foundation is one of the most influential factors where overall reliability of a unit is concerned. A foundation must maintain alignment under all normal and abnormal conditions. The includes the way the foundation is supported on the soil and/or superstructure, equal deflections of all columns under load, soil settling and soil resonances, thermal distortion, piping forces vacuum pull or pressure forces in expansion joints.

1.2 The foundation must minimize vibration by being as heavy as possible and non-reasonant. It is important that the turbine be isolated from external vibration by providing an air gap filled with mastic sealer all around the slab and mat.

1.3 Provision in design must be adequate when a turbine unit is carried on steel work or other structure, as applied to foundations in soil. Structure must be stiff enough to prevent yielding or springing. The addition of a substantial concrete mat will minimize vibration. It is essential that no part of the foundation or structure is resonant within the operating speed range of the machine.

1.4 Vibration transmissions may be from the unit to the surroundings or vice-versa, and it may be aggravated by resonance at transmission frequencies, piping, stairways, and ducts may also transmit vibration, which should be prevented by proper isolation.

1.5 Certified general outline drawings are furnished with each order. Those drawings include dimensions for locating anchor bolts, weight of each assembly and general information needed for determining foundation size and thickness.

1.6 A generous factor of safety should be used when determining foundation thickness. The foundation length and width should extend at least six inches (6") beyond the anchor bolts.

INSTALLATION CONTINUED....

1.7 Anchor bolts must be positioned accurately and provided with sleeves (see figures 1 and 3). The sleeve bore diameter should be approximately twice the bolt diameter, but should provide not less than one half inch (1/2") clearance all around the bolt.

1.8 Carefully constructed templates are required to hold bolts and sleeves in position while foundation is cast. Templates are usually made of wood and secured to the foundation forms. Skilled craftsmen should be able to set anchor bolts to a tolerance of one-eight inch (1/8") by locating and drilling the holes in the templates after they have been secured to the braced forms.

1.9 The anchor bolts should be threaded at both ends and of sufficient length to extend one and one-half (1 1/2) to twice (2) the bolt diameter above the top of the securing holes in the base of the sole plate. The lower end of each bolt passes through an anchor plate and is secured by a nut and welded (see figure 1).

1.10 Anchor plates can be either standard cast iron washers or flat steel plates. They should have a diameter of approximately twice to two and a half times (2 to 2 1/2) the outside diameter of the sleeves.

NOTES:

A. The templates must be rigid enough to prevent bolts from shifting while the concrete is being poured.

B. After concrete has been poured and before it has hardened, recheck the position of the anchor bolts.

C. Allow one half (1/2") to one inch (1") gap above the top of the foundation surface for grouting under the edge of base or sole plates.

2. LEVELING

2.1 Sufficient parallel machined bearing plates or chock blocks should be placed beneath soleplates or base and along the sides and ends to distribute the load evenly.

2.2 It is essential that they are leveled before the soleplates or base are placed in position. For leveling use an optical method or a level of a very high quality with a ground calibrated dial. Obtain an accurate condition of level lengthwise and crosswise.

2.3 Shims should be used to adjust height of sole plates or base to align turbine and driven equipment (see figures 1 & 2). Allowances must be made for the turbine horizontal centerline rise due to thermal expansion relative to that of the driven equipment (See Section 4 - ALIGNMENT).

NOTE

Shims supplied under turbine feet or flexplate supports are not for initial installation alignment, but for final alignment after a "HOT RUN" check.

2.4 In an installation involving a gear drive between the driver and driven unit, installation procedure should be to align the driver and driven unit to the gear to achieve minimum error.

2.5 When units are attached to a common base wedges or jacking bolts can be used to initially adjust alignment (See figure 2).

3. GROUTING

3.1 The anchor bolts are used for hold down only. The grouting resists side thrust, end thrust, and compensates for the irregularities between foundation and base, thus preventing turbine and driven unit or units from shifting.

INSTALLATION CONTINUED....

3.2 Terry recommends that all machinery bases be grouted. This should provide structural damping along with uniform and continuous support, from machinery feet through base grout to concrete foundation, of sufficient stiffness to kept support resonances above operating speed range. To achieve desired structural integration, non-shrink grout must be used exclusively, with an epoxy grout layer at grout-to-base-deck interface, for a high-strength bond. The base itself must be regarded as a shell or form in which grout hardens to a structural block which alone transmits machinery forces to underlying foundation. Internal base reinforcement furnished by Terry is limited to that required to minimize base distortion during shipment and setup.

3.3 Bases shall be provided with 6 inch (152mm) minimum diameter grout fill holes fitted with steel pipe sections which extend at least 0.5 inches (13mm) above deck surface. These fill holes are to be spaced so that every compartment within base structure may be immediately accessible for placement of grout, but not less than one (1) fill hole for every 16 square feet ($1.5m^2$) of deck section.

3.4 For every fill hole, two 2 inch (51mm) diameter vent holes shall also be provided, fitted with similar pipe sections, 0.5 inch (13mm) above deck surface. Vent holes are to be placed in corners where air is likely to be trapped.

3.5 Acceptable grouting materials are non-shrink, non-expanding, portland cement base grout, and epoxy grout. Both grouts may be extended up to fifty percent (50%), with clean aggregate consistent with manufacturer's recommendations.

A. Portland cement grout may be extended with coarse aggregate.

B. Epoxy grout may be extended with sand only.

3.6 Grout must be mixed and placed according to the following procedure. The concrete foundation top surface must be roughened, cleaned, and moistened, but with no free standing water. Steel surfaces in contact with grout must be free of rust, scale, paint, and grease, preferably by sandblasting. Cement grout must be mixed as "stiff" (minimum slump) as possible and rodded or vibrated into place to eliminate voids. Manufacturer's maximum thickness per pour, cure time, and cure procedure are to be observed. Epoxy grout must be used in a liquid condition and poured in such quantity as to fill base to top of protruding pipe sections above deck surface. This provides a liquid pressure head assuring a grout structure reasonably free of voids and air pockets which maximizes structural integration and eliminates deck "drum head" effects.

3.7 The majority of base cavity is to be filled with cement grout. Cement grout must be poured to a level no higher than one inch (25mm) below deck surface. The top of base cavity must be epoxy grouted.

NOTES:

A. Allow grouting to set before tightening anchor bolts. After tightening, check alignment to make sure it has not changed.

B. Do not connect piping to turbine until alignment and grouting are completed.

4. LIFTING

4.1 Before lifting heavy equipment, be certain that weights listed on certified outline drawings are within the capacity of the crane or hoist. Lift smoothly and avoid twisting and shock damage. Adjust cable or chain lengths to lift squarely. Use wooden block pads, etc., to prevent cables or chains from damaging pipe work or turbine parts.

4.2 When turbines are mounted on a base and are equipped with a sliding expansion foot on the bearing pedestal at the governor or high pressure end of the lower half casing, the sliding foot is secured to the base by two bolts, one on each side within the guide blocks. THESE BOLTS ARE NOT DESIGNED TO TAKE THE WEIGHT OF LIFTING THE ASSEMBLY. Chock washers are fitted under bolt heads to secure pedestal foot from movement during shipment. DO NOT REMOVE UNTIL UNIT IS INSTALLED.

5. PIPING

5.1 The piping system should be designed with sufficient inherent flexibility to take care of thermal expansion without creating excessive forces at the flanges.

5.2 On both the inlet and exhaust pipes a suitable support (adjustable spring loaded) should be installed directly under vertical risers near the turbine and above horizontal pipe runs, and then adjusted for best possible alignment of flange when hot. This will insure that most of the forces resulting from expansion and stresses due to dead weight will not be placed on the turbine flanges.

IMPORTANT NOTE

The piping must be so arranged and so supported that no excessive stress can be transmitted to the turbine, either due to the weight of the pipe or to its expansion and contraction.

All piping must be within the limits of the allowable forces and moments in accordance with the applicable NEMA standards publication. The only exception being when allowable forces and moments are included on a certified outline drawing for a particular project.

5.3 PIPING STRAIN

5.3.1 The net effect of piping strain on a machine reduces reliability by:

5.3.1.1 Causing misalignment and consequent vibration.

5.3.1.2 Causing case distortion and consequent vibration, rubs, case leakage and possible cracking.

5.3.1.3 Causing foundation or base deflection, which may result in misalignment, case distortions and consequent vibrations or rubs.

5.3.2 Excessive piping strain may be the result of:

5.3.2.1. Thermal expansion and contraction of the pipe, boiler, and machine. This indicates faulty piping design. Expansion joints or loops may have to be installed to correct the problem.

5.3.2.2. Improper pipe support. Frequent problems arise from indiscriminate use of rod hangers (instead of spring hangers), anchors, and other non-elastic restraints and supports. To correct this, disconnect piping at both ends and support on spring hangers except where anchors or restraints are required by the pipe design.

5.4 Inlet pipe sizes should be large enough to maintain rated steam pressure at the turbine inlet flange under maximum load conditions. In determining pipe size, proper allowance should be made for pressure drop due to long sections of pipe, elbows, valves or other fittings between the boiler and the turbine.

5.5 If wet or saturated steam is used, it is very important that the piping be arranged so that condensate cannot be carried over into the turbine. A steam separator of the proper size with a trap of ample capacity, should be installed before the turbine inlet. If the turbine is fed from a main header under no circumstances should the pipe be taken from the side or bottom of the header. IT SHOULD, IN ALL CASES, BE FED FROM THE TOP. All horizontal runs must be sloped in direction of steam flow, with drains at the low points.

5.6 The importance of protecting the turbine against slugs of water cannot be over-emphasized. We are not concerned with the wetness of the steam, but with the condensate which is separated out as water.

5.7. The harmful effects of water are:

5.7.1. Rapid erosion of blading and valves.

5.7.2. In the case of wheels with inserted blades, the danger is present of the hammer blow effect of the water tearing out the blades and damaging the rotor.

5.7.3. Governing is adversely affected.

5.7.4. Rotor may be permanently distorted and/or turbine damaged.

5.7.5. Danger of thrust bearing failure and consequent damage to turbine.

5.8 Exhaust piping. On each installation the length of run, elbows, valves and other fittings in the pipe must be considered and all factors which may cause excessive back pressure on non-condensing turbine or reduced vacuum on condensing turbines, and the final decision on piping size made accordingly. On non-condensing turbines, back pressure higher than that for which the turbine was designed will cause a reduction of power and an increase of steam consumption. It may also cause gland leakage and, in extreme cases, can rupture the turbine casing. On condensing turbines decrease of vacuum will have an even greater effect on capacity and economy.

5.9 The exhaust pipe must be installed and anchored so that no excessive stress can be put on the turbine from either the weight of the pipe or its expansion and contraction. Where such arrangement cannot be made with certainty the provision of an expansion joint near the turbine can be useful in low pressure lines and is usually required on large pipe sizes.

5.9 The use of an expansion joint does not of itself avoid undue stress. It is not as flexible as many people assume and when installed it must be properly aligned and not indiscriminately exposed to shear or torsion. In a majority of applications the axial thrust created on the cross sectional area of the largest bellows by internal pressure, must be restricted by the use of the rods. They are most effective when the expansion joint is used in shear, instead of tension or compression. When used in either a vacuum or a pressure line, the tie rods have to be arranged accordingly. They are useless where a joint moves under tension and compression as they by-pass the joint and transmit pipe forces direct to the turbine. Provision must be made to anchor the piping in such a manner that excessive forces will not be transmitted to the turbine during shutdown and operational running. (SEE NEMA STANDARDS IN THIS SECTION). As on inlet lines, connection to a header must be made at the top-never from the side or bottom, and great care must be taken to avoid draining water back into the turbine. All horizontal runs must be sloped.

6. FULL-FLOW RELIEF VALVE

6.1 An atmospheric full-flow relief valve is part of the exhaust piping which is external to the turbine and it must be installed in the exhaust piping between the turbine exhaust connection and the first shutoff valve in the exhaust system. This is to protect the turbine casing and internal parts against excessive steam pressure.

6.2 The valve must be sized to pass the maximum steam flow, to the atmosphere, that will pass through the turbine nozzles under rated initial steam conditions.

NOTE

THIS VALVE IS NOT TO BE CONFUSED WITH THE SENTINAL RELIEF VALVE INSTALLED ON THE TURBINE CASING TO GIVE AUDIBLE AND VISUAL WARNING OF EXCESSIVE EXHAUST PRESSURE.

6.3 The full-flow relief valve should start to open at the sentinal relief valve setting and be fully open with the additional rise in pressure not to exceed ten (10) percent (NEMA STANDARDS CODE). The sentinal relief valve will then give a visual and audible indication when the full-flow relief valve starts to open.

CAUTION NOTICE

THE EXHAUST CASE IN NOT DESIGNED FOR FULL LINE PRESSURE AND MUST BE PROTECTED WITH A SUITABLE SAFETLY DEVICE SUCH AS A FULL-FLOW RELIEF VALVE TO PREVENT OVER PRESSURIZATION OF THE EXHAUST CASE.

7. CHECK VALVE

7.1 When a turbine exhausts or bleeds steam into another system and a check valve is installed to provide containment of reverse flow to the turbine, adequate bracing must be installed to absorb any forces created by water hammer occurring in the exhaust line downstream and acting on the check valve.

8. AUXILIARY PIPING

8.1 When water cooling is indicated on certified outline drawings the inlet pipes must be provided with valves for regulating. NEVER INSTALL VALVES IN OUTLET PIPES! Output pipes must be so arranged that they cannot become obstructed. Only clean, cool water should be used. Cooling water piping should be sized to suit the connections on the cooler. The amount of cooling water will vary, depending on the temperature of the water, steam temperatures, etc. With forced feed lubrication, the flow of water should be adjusted to maintain an oil temperature leaving the bearings not to exceed 165^{o}F (74^{o}C)., and an inlet temperature not under 100^{o}F (38^{o}C).

8.2 Every turbine is provided with one or more drain outlets. These should be piped with suitable OPEN atmospheric drain lines and shutoff valves must be provided. These drain lines must be left open when the turbine is idle to prevent accumulation of condensate in the turbine which will result in corrosion and rapid deterioration of internal parts. INSURE THAT NO CONDENSATE CAN BE PULLED INTO THE TURBINE THROUGH THE DRAIN LINES.

8.3 If turbine is subjected to freezing temperatures water must not be allowed to stand in cooling coils or pockets in the case, steam chest or valves.

9. OIL PIPING AND GLAND PIPING

9.1 Instructions are provided in the Lubrication and Steam Seal-Drain System sections in this manual.

10. CLEANING OF STEAM PIPING

10.1 Terry Corporation has found from experience over many years, with different customers, that it is very important to clean steam piping and headers, especially with new installations, before a steam turbine is put into operation. There have been cases where steam lines have not been cleaned at all, with the idea that strict inspection for cleanliness during installation would be sufficient. This has proven unsatisfactory since very small particles of steel, welding slag and large quantities of oxide scale have been blown into the turbine through the small strainer holes of the turbine governor or stop valve.

10.2 From experience it has been found most satisfactory to blowdown steam lines with steam using a cycle of heating, blowing and cooling. This method is recommended by Terry Corporation.

NOTE

The following procedure suggested by Terry Corporation is not mandatory. The purchaser is at liberty to employ other accepted methods. IN EITHER CASE, IT MUST BE CLEARLY UNDERSTOOD THAT IT IS THE PURCHASER'S RESPONSIBILITY TO SUPPLY STEAM FREE OF FOREIGN MATERIAL TO THE TURBINE INLET CONNECTIONS.

10.3 SUGGESTED BLOWDOWN PROCEDURE. Due to the variations in different installations of the length, configuration, number of stop valves and sizes of steam piping it is not intended or possible to give a detailed procedure.

NOTE

WHEN CLEANING STEAM PIPING IT MUST BE DISCONNECTED FROM THE INLET TO THE TURBINE OR THE TURBINE STOP VALVE.

10.3.1 The purchaser must plan and make proper arrangements to achieve maximum cleaning of piping. The blowdown cycle consists of warming the steam lines initially. Then, design pressure for the piping is built up in the boiler and released through the valve to blow through the steam line. Blowing should be stopped before boiler pressure drops to 100 PSIG or the minimum pressure recommended by the boiler manufacturer.

10.3.2 Boiler pressure is then built up again, during which time the steam line should be cooled enough and the cycle can be repeated.

10.3.3 The cycle should be repeated from four (4) to six (6) times. The use of targets installed in the steam path are recommended as they give a good indication as to the cleanliness of the line. Targets should have a highly polished finish and be repolished after each blowdown check.

10.3.4 To achieve maximum cleaning during the blowing cycle, the blow piping should be sized large enough to obtain the maximum mass velocity head that can be developed during full load operation of the turbine.

10.3.5 The blow pipe should be piped outside of the building where the blowdown steam and particles will not injure personnel or damage equipment. It should also be of the same design rating of the steam line being blown down.

10.3.6 The purchaser must decide as to whether the steam line should be blown down by sections, stop valve to stop valve or direct from boiler to stop valve, according to the system layout and keeping in mind that the maximum velocity must be maintained to achieve maximum cleaning.

NOTE

THE FINE MESH SCREEN MUST NEVER BE CONSIDERED AS A SUBSTITUTE FOR A THOROUGH PIPE CLEANING JOB.

10.4 EXHAUST PIPING

NOTE

WHEN CLEANING STEAM EXHAUST PIPING IT MUST BE DISCONNECTED FROM THE TURBINE EXHAUST.

10.4.1 Put blind between exhaust flange and exhaust pipe to prevent foreign materials from entering the case during the blowdown process.

10.4.2 Open exhaust valve slowly. This allows condensate and steam to wash out exhaust piping.

10.4.3 Repeat step 10.4.2 until system is clean.

11. EXPANSION JOINTS

WARNING

DO NOT PERMIT CINDERS OR OTHER FOREIGN MATERIAL TO BECOME LODGED BETWEEN THE EQUALIZING RINGS AND THE CORRUGATIONS.

11.1 Expansion joints 5" and smaller in size are shipped with two (2) spacing blocks between the equalizing rings. These must be removed before pipe spacers between the equalizing rings. These should not be removed until joint is set in place in the line, but must be removed before the joint is permitted to function.

11.2 Flanged expansion joints having internal sleeves require a soft gasket between the face of the joint and the back of the sleeve face as well as gasket between the sleeve and the companion flange. Those joints should be installed so that the flow is in the inner sleeve.

11.3 The universal type of expansion joint has two (2) or four (4) heavy limit rods which divide the movement equally between both expansion joints. Each of these rods have four (4) split spacing collars under the nut. These maintain the proper overall length and should only be removed after the joint is bolted in place.

WARNING

GASKETS CONTAINING CARBON OR GRAPHITE SHOULD NOT BE USED IN CONTACT WITH STAINLESS STEEL. SEVERE CORROSION MAY RESULT. ANY DARK COLORED GASKET MAY CONTAIN GRAPHITE: CONSULT GASKET MANUFACTURER.

SUGGESTED ARRANGEMENT OF SOLEPLATES AND GROUTING
(Figures 1 through 3)

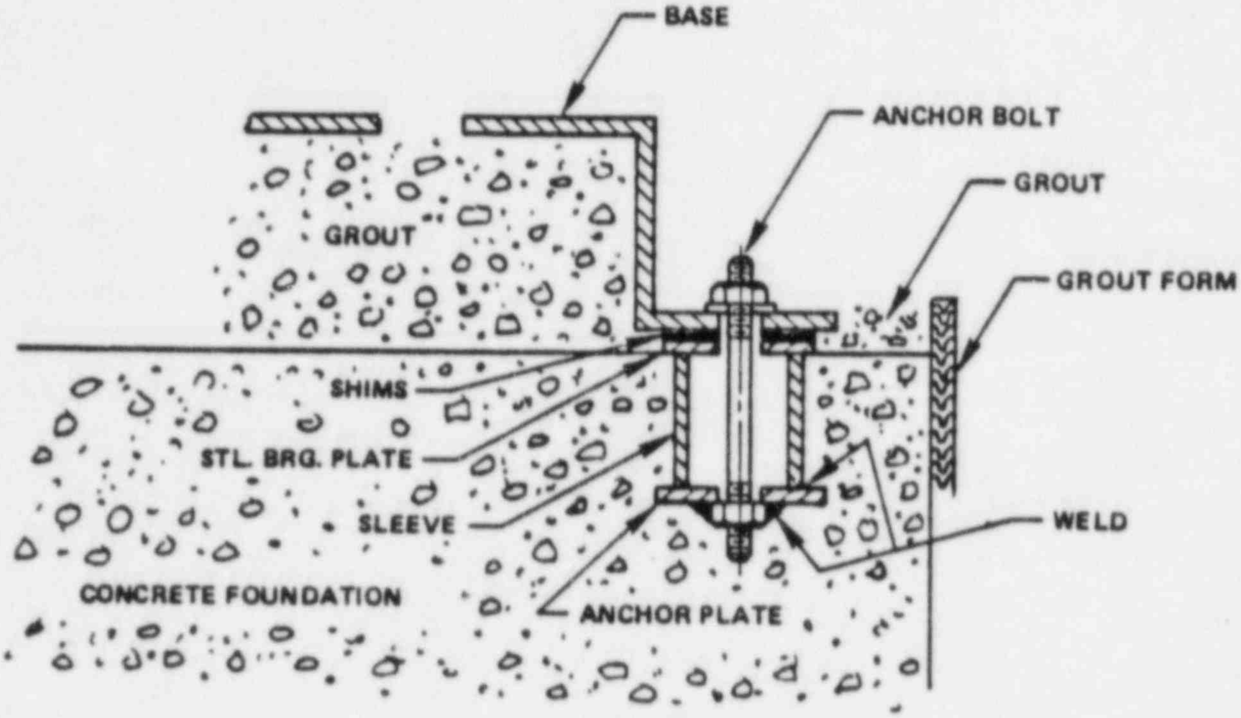


Figure 1

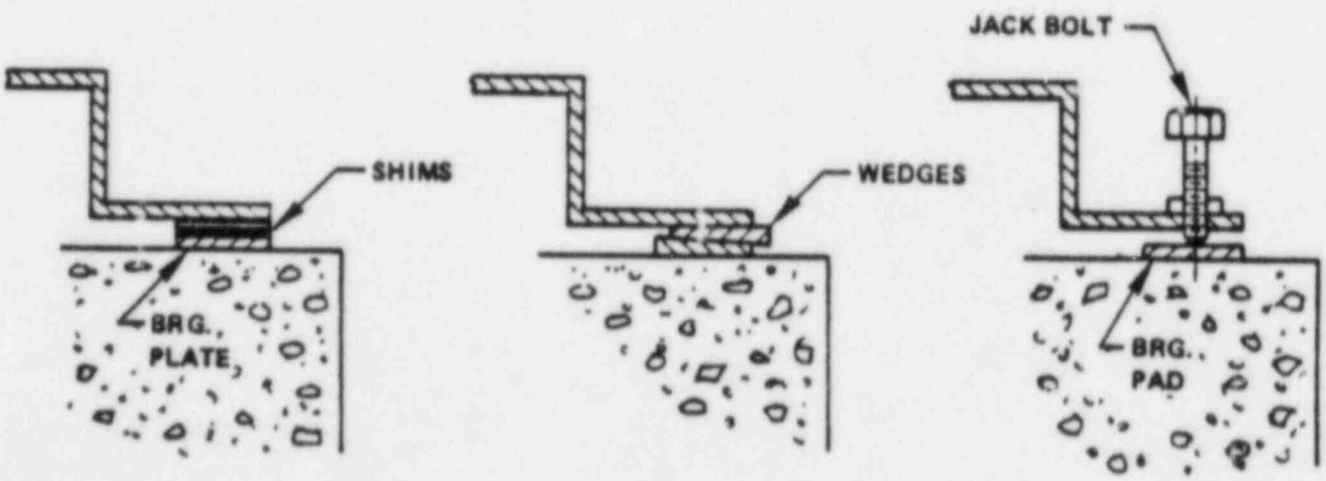
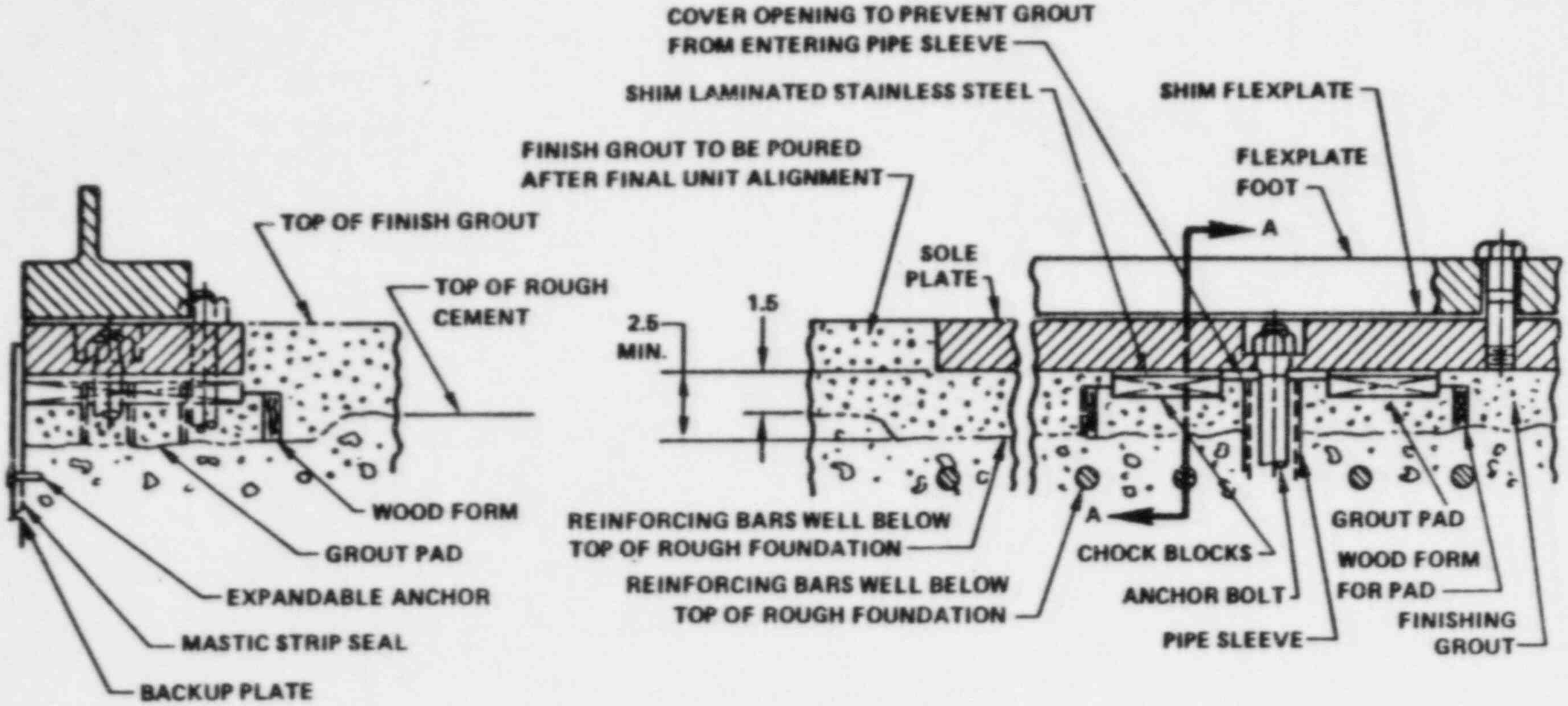


Figure 2

NOTE: When using Jack bolts or wedges to establish alignment before grouting they should be backed off or removed after the grout has set and the anchor bolts should be tightened.



SECTION A-A

Figure 3

INSTALLATION

This page is included as a location reference for the following extract as taken from the National Electrical Manufacturers Association (NEMA) Standards Publication No. SM23-1979, for which due credit is acknowledged.

It is included in this Instruction Manual as a guide for the minimum requirements of installation, except that, where allowable forces and moments are shown on certified outline drawings, pipe loads are to be kept within those limits shown.

Part 8

STEAM PIPING SYSTEMS

SM 23-8.01 INTRODUCTION

Reactions of piping systems connected to steam turbines, if of sufficent magnitude, will result in misalignment of the turbine sufficient to cause rough operation and serious mechanical damage. Steam turbines have been very carefully designed to provide for thermal expansion and, at the same time, maintain close alignment between the turbine rotating and stationary parts, and also the turbine and driven equipment. The provisions for turbine thermal expansioins by necessity limit the allowable values of forces and moments applied to the turbine structure by the piping connected to it.

It is the purpose here to briefly discuss piping arrangements and recommend flange loading limitations imposed on mechanical-drive steam turbines by piping. This information is presented as an aid to the purchaser and is not intended as a self-contained thesis on piping.

The recommendations to be discussed should provide allowable values of forces and moments at the turbine connections for steam inlet, extracting, and exhaust piping.

It is not considered necessary to supply values for auxiliary piping such as steam leak-off, lubricating oil, and cooling water, but even so, this auxiliary piping should also be designed such that turbine expansion is not restrained.

Authorized Engineering Information 6-21-1979.

SM 23-8.02 THE PIPING PROBLEM AS APPLIED TO TURBINES

One of the first considerations in designing any piping system is to keep the stresses in the pipe within the limits of the established rules of national codes such as the ASME *Boiler and Pressure Vessel Code*, American National Standard B31.3, *Chemical Plant and Petroleum Refinery Piping*, and any local codes that may be applicable. In general, the jurisdiction of such authorities stops at the turbine inlet and exhaust connections or other openings on the machine to which external piping systems connect.

In order to keep the strains due to forces and bending moments on the turbine connections, including the weight of the pipe, within recommended limits, the piping system design should be such that restraints and freedom of movement match the requirements of the turbine. Pipe forces which seem small may lead to large moments at the connections to the turbine and to very large forces at the turbine supports.

The forces in a piping system under operating conditions can be grouped into three classes: those due to steam pressure, temperature, and dead weight.

Authorized Engineering Information 6-21-1979.

SM 23-8.03 FORCES DUE TO STEAM PRESSURE

These are most commonly associated with low-pressure and vacuum lines where expansion joints are often used to provide flexibility. If an expansion joint is improperly used, it may cause a pipe reaction greater than the one which it is supposed to eliminate. An unrestrained expansion joint will cause an axial thrust equal to the effective area of the bellows times the internal pressure. The force necessary to compress or elongate an expansion joint can be quite large, and either of these forces may be greater than the limits for the exhaust flange. In order to have the lowest reaction, it is best to avoid absorbing pipeline expansion by axial compression or elongation. If it is found that expansion joints are required, consult the Expansion Joint Manufacturers Association.*

The following figures and paragraphs represent typical installations and are offered only as guides.

Fig. 8-1 shows an expansion joint in a pressure line. The axial thrust from the expansion joint tends to separate the turbine and the elbow. To prevent this, the elbow should have an anchor to keep it from moving. The turbine should also absorb this thrust and, in doing so, becomes an anchor. This force on the turbine case may be greater than can be allowed. In general, this method should be discouraged.

Fig. 8-2 shows the same piping arrangement as Fig. 8-1, except for the addition of tie rods on the expansion joint. The tie rods prevent the elongation of the joint and take the axial thrust created by the internal pressure of the expansion joint so it is not transmitted to the turbine flange. The tie rods eliminate any axial flexibility, but the joint is still flexible in shear; that is, the flanges may move in parallel planes. The location of this type of joint in the piping should be such that movement of the pipe puts the expansion joint in shear instead of tension or compression.

* EJMA, 331 Madison Avenue, New York, New York 10017.

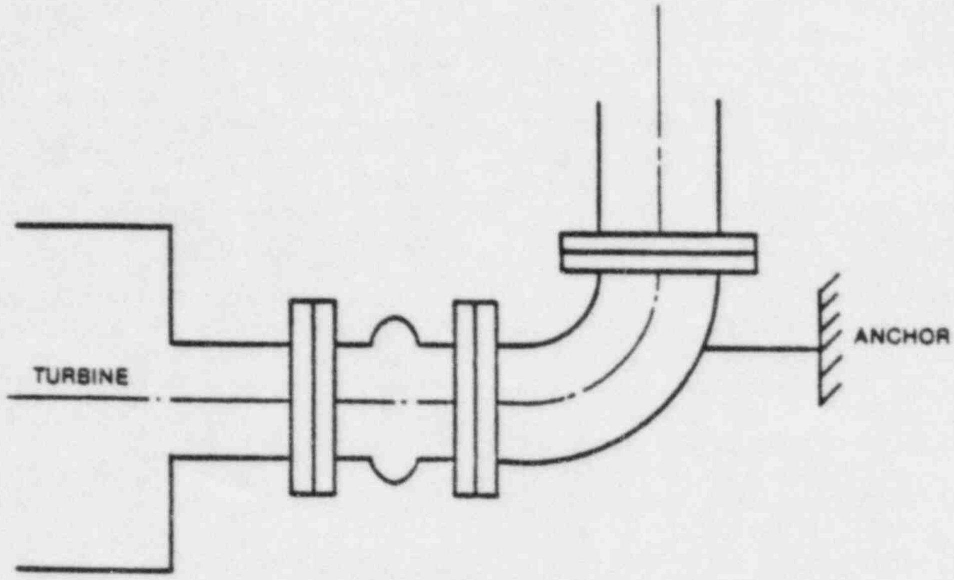


Fig. 8-1
EXPANSION JOINT

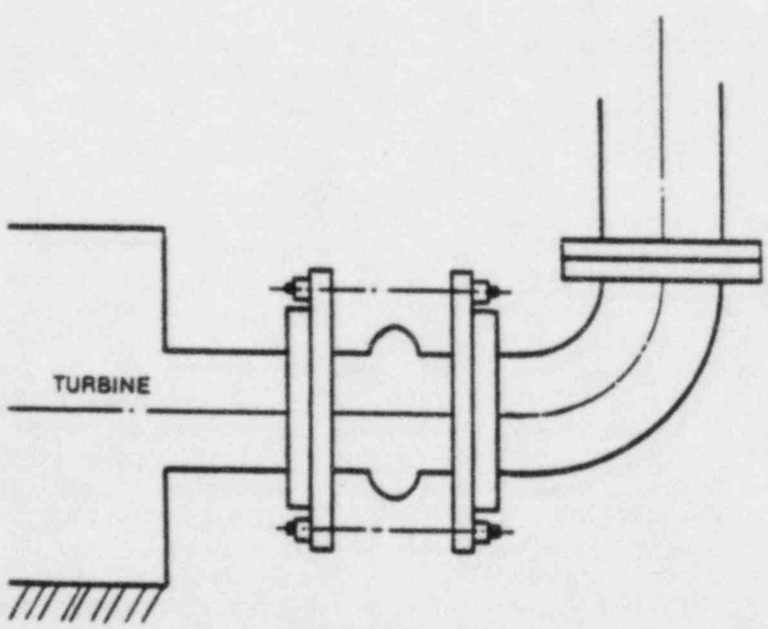


Fig. 8-2
EXPANSION JOINT WITH TIE RODS

Fig. 8-3 is an arrangement frequently used, having tie rods as indicated for noncondensing operation. This arrangement should prevent any thrust due to internal pressure of the expansion joint from being transmitted to the exhaust flange and retains the axial flexibility of the joint. It may be used for either vacuum or pressure service (by suitable arrangement of tie rods).

Fig. 8-4 shows a suggested arrangement for a condensing turbine with an "up" exhaust. Due to the large exhaust pipe size normally encountered on condensing turbines, the exhaust piping may be relatively stiff, and an expansion joint should be used at some point to take care of thermal expansion. An unrestricted expansion joint placed at the exhaust flange of the turbine may exert an upward or lifting force on the turbine flange which in many cases is excessive. Fig. 8-4 provides the necessary flexibility to take care of thermal expansion without imposing any unnecessary lifting force on the turbine. The expansion joint is in shear which is the preferred use. The relatively small vertical expansion may compress one joint and elongate the other which causes a small reaction only and may be well within the turbine flange limits.

Authorized Engineering Information 6-21-1979.

SM 23-8.04 FORCES DUE TO TEMPERATURE

If a pipe is connected to some point as A in Fig. 8-5, and has the configuration shown by the solid line, it may assume the approximate position shown by the dash line when heated to a higher temperature, providing no restraint is offered by point B.

If both points A and B are rigid points which may not move, the pipe may assume a shape similar to that shown by the dash line in Fig. 8-6 when heated.

The stresses may be reduced by using expansion loops such as shown in Figs. 8-7 and 8-8. When the piping does not have to be confined to one plane, torsional flexibility may be effectively used to reduce stresses. Prestressing the pipe in the cold condition or "cold springing" may also be used to reduce the stresses in operation. These principles may be used in combination to produce a design with flexibility sufficient to keep the stresses, forces, and moments within the permissible limits in both the hot and cold conditions.

The piping system should be designed with sufficient inherent flexibility to take care of thermal expansion. Prestressing (cold springing) to reduce the maximum values of both connection reactions and piping stress is accomplished by cutting the pipe short by a predetermined amount and then forcing it into place during installation as illustrated in Fig. 8-9. Forces and moments in the hot condition are thus reduced below the values they would have if the system were not cold-sprung. Points A and C of Fig. 8-9 are the points to be connected by a piping system and X and Y are the respective expansions.

In the case of welded connections, it is necessary to bend the pipe by putting a moment on it when connecting it to point C to make the weld preparations parallel, as well as just pulling B up to C. If this is not done, a moment may exist in the hot condition, and desired reduction in forces and moments may not be obtained. Wherever possible, it is wise to facilitate assembly by locating field welds at points of minimum moment. Points D and E are such points.

Authorized Engineering Information 6-21-1979.

SM 23-8.05 FORCES DUE TO DEAD WEIGHT

The dead weight of the piping should be entirely supported by pipe hangers or supports. There are basically two types of supports—rigid and spring. Rigid supports are necessary when an unrestricted expansion joint is used. Rigid supports may be used to limit the movement of a line to prevent excessive deflection at any point. A rigid support is not satisfactory where thermal expansion may cause the pipe to move away from the support.

On the two types of rigid supports shown in Fig. 8-10, the rise of the turbine case due to temperature may lift the base elbow from the support so the turbine would have to support the weight of the pipe. The expansion of the vertical run of pipe would relieve the pipe hanger of its load so the turbine would again have to support the weight of the pipe.

If an expansion joint with restraining tie rods is used, either a rigid pipe hanger or a base elbow with a sliding or rolling contact surface can be used as shown in Fig. 8-11.

When the thrust due to an expansion joint is less than the exhaust flange limits and no restraining tie rods are used, the pipe should have an anchor as shown in Fig. 8-12. Since this condition rarely exists, it is better to use one of the preferred arrangements such as shown in Fig. 8-11 and eliminate as much pipe reaction as possible rather than just stay within the limits.

Spring hangers or supports are best suited to carry the dead weight when there is thermal expansion to be considered. The movement of the pipe may change the spring tension or compression a small amount and the hanger loading a small amount but may not remove the load from the hanger. Published manuals

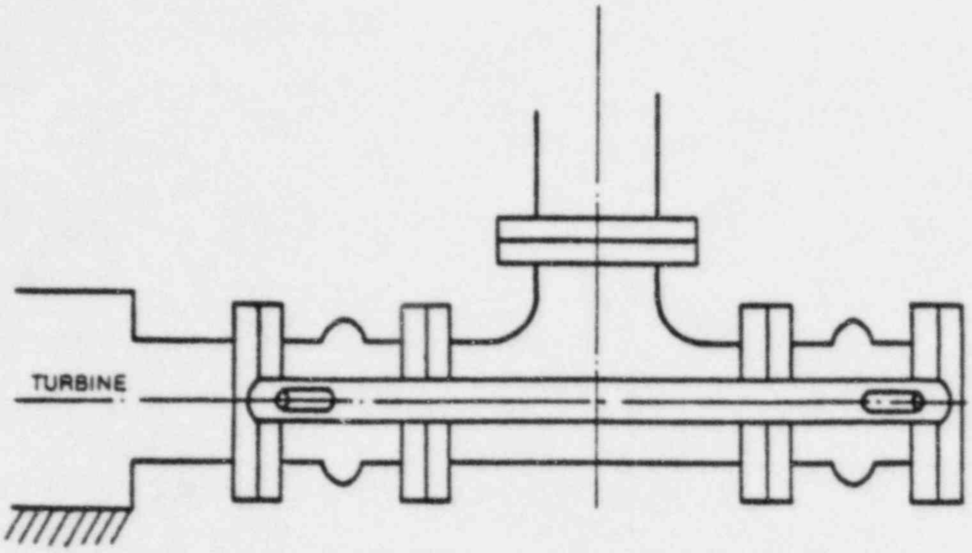


Fig. 8-3
EXPANSION JOINT WITH TIE RODS
FOR NONCONDENSING OPERATION

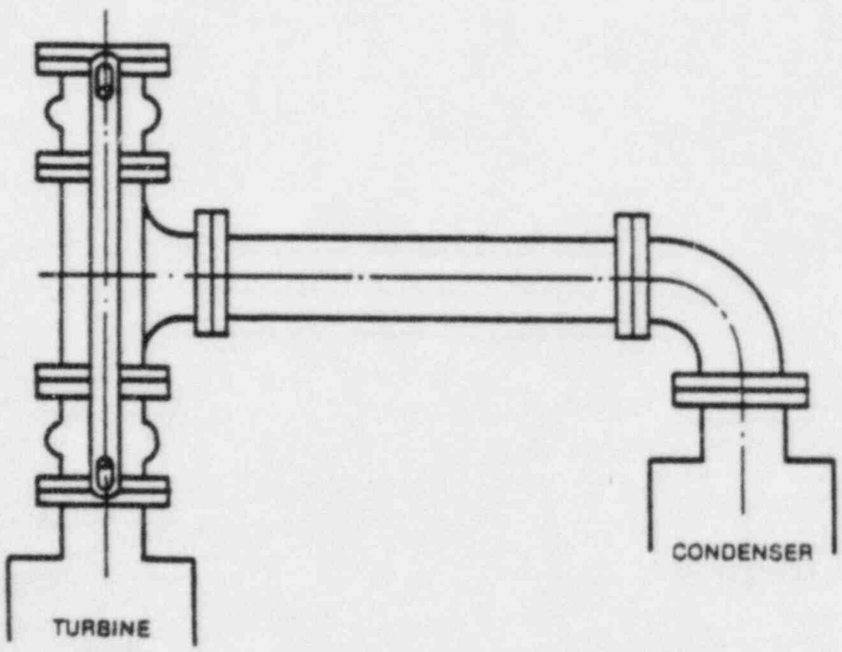


Fig. 8-4
EXPANSION JOINT WITH TIE RODS FOR
CONDENSING OPERATION WITH "UP"EXHAUST

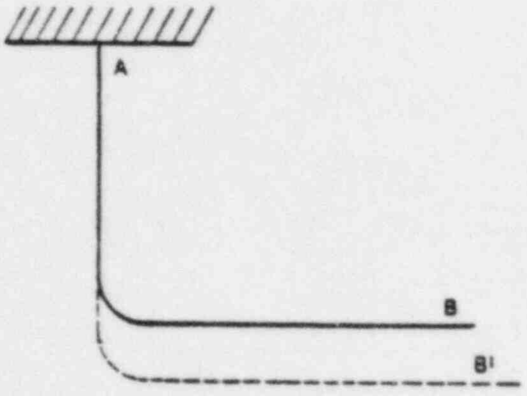


Fig. 8-5

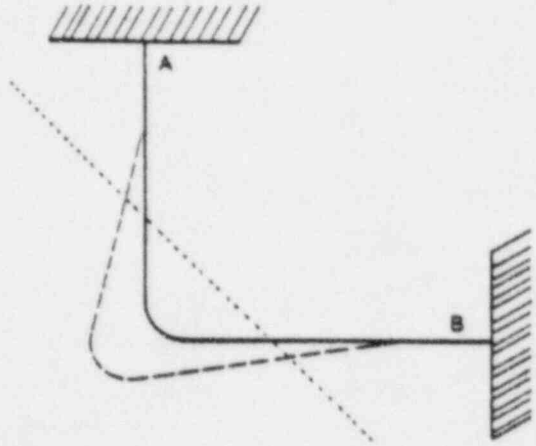


Fig. 8-6

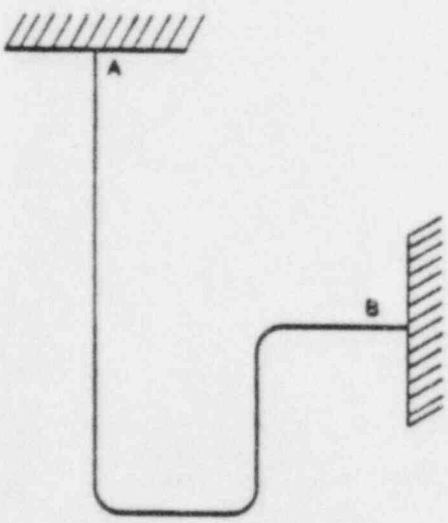


Fig. 8-7

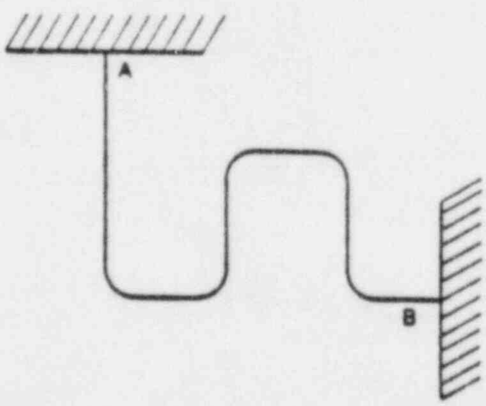


Fig. 8-8

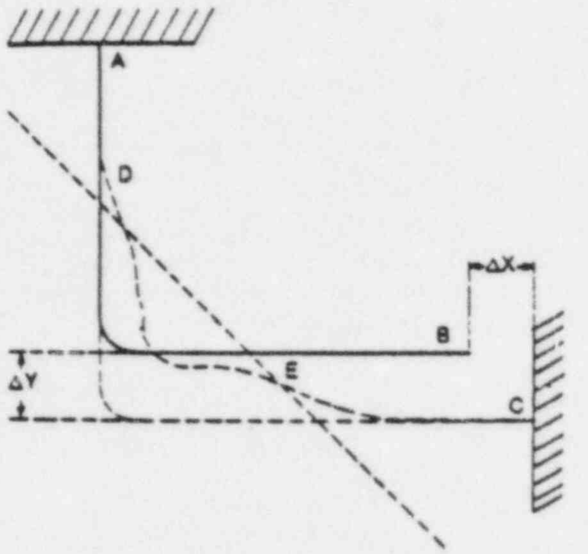


Fig. 8-9

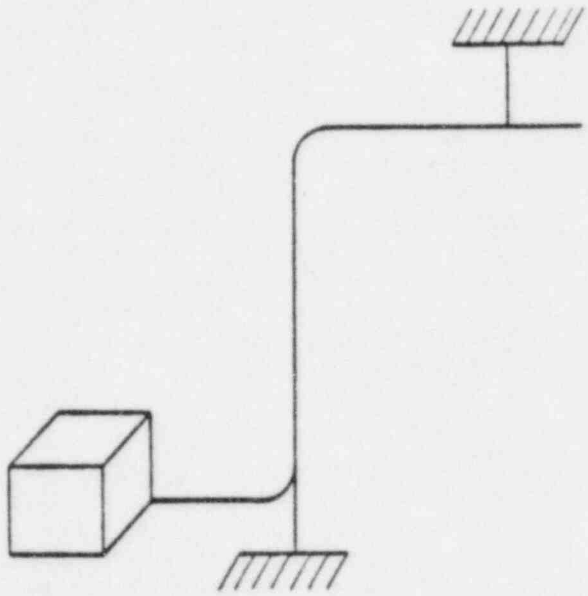


Fig. 8-10

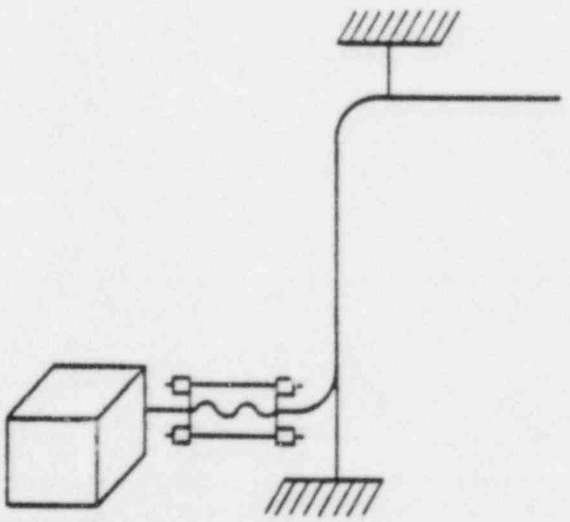


Fig. 8-11

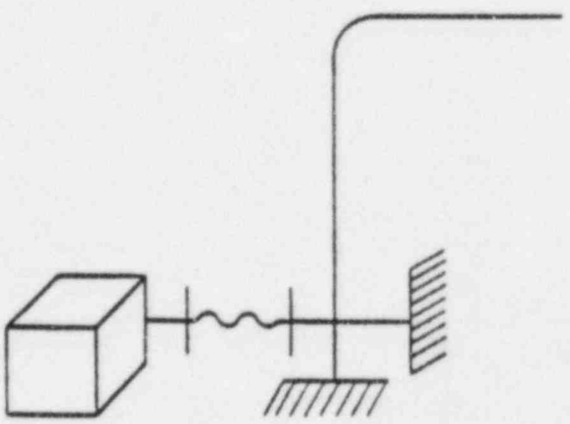


Fig. 8-12

on pipe design provide information on hanger spacing to give proper support. In addition to this, it may be found necessary to add additional supports or move existing supports if resonant vibration appears in the piping.

A spring support should not be used to oppose the thrust of an expansion joint. when the pressure is removed from the line, the spring support may exert a force the same as the expansion joint only in the opposite direction.

Authorized Engineering Information 6-21-1979.

SM 23-8.06 ALLOWABLE FORCES AND MOMENTS ON MECHANICAL DRIVE STEAM TURBINES

The forces and moments acting on mechanical drive steam turbines due to the steam inlet, extraction, and exhaust connections may be limited by the following rules:

1. The total resultant force and total resultant moment imposed on the turbine at any connection must not exceed the following per Fig. 8-13:

$$F_R + \frac{M_R}{3} = 167\ D_e$$

where:

F_R = Resultant force (pounds) including pressure forces where unrestrained expansion joints are used at the connection except on vertical exhausts. Full vacuum load is allowed on vertical down exhaust flanges. It is not included as part of the piping load.

$$F_R = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

M_R = Resultant moment in foot-pounds

$$M_R = \sqrt{M_x^2 + M_y^2 + M_z^2}$$

D = Nominal pipe size of the connection in inches up to 8 inches in diameter.

For sizes greater than this, use a value of

$$D_e = \frac{(16 + D_{nom})\ \text{inches}}{3}$$

2. The combined resultants of the forces and moments of the inlet, extraction and exhaust connections, resolved at the centerlines of the exhaust connection must not exceed the following two conditions:

a. These resultants shall not exceed:

$$F_c = \frac{250\ D_c - M_c}{2}$$

where:

F_c = Combined resultant of inlet, extraction, and exhaust forces, pounds.

M_c = Combined resultant of inlet, extraction, and exhaust moments, and moments resulting from forces, pound-feet.

D_c = Diameter (in inches) of a circular opening equal to the total areas of the inlet, extraction, and exhaust openings up to a value of 9 inches in diameter. For values beyond this, use a value of D_c equal to:

$$\frac{(18 + \text{Equivalent diameter})}{3} = \text{inches}$$

b. The components of these resultants shall not exceed:

$F_y = 125\ D_c$	$M_y = 125\ D_c$
$F_z = 100\ D_c$	$M_z = 125\ D_c$
$F_x = 50\ D_c$	$M_x = 250\ D_c$

The components are as follows:

F_y = Vertical component of F_c.

F_z = Horizontal component of F_c at right angles to turbine shaft.

F_x = Horizontal component of F_c to turbine shaft.

M_x = Component of M_R in a vertical plane at right angles to turbine shaft.

M_y = Component of M_c in a horizontal plane.

M_z = Component of M_c in a vertical plane parallel to the turbine shaft.

3. For installation of turbines with a vertical exhaust and an unrestrained expansion joint at the exhaust, an additional amount of force caused by pressure loading is allowed. (This additional force is perpendicular to the face of the exhaust flange and central.) For this type of application, calculate the vertical force component on the exhaust connection excluding pressure

loading. Compare this with one sixth of the pressure loading on the exhaust. Use the larger of these two numbers for vertical force component on the exhaust connection in making calculations outlined in items 1 and 2.

The force caused by the pressure loading on the exhaust is allowed in addition to the values established by the foregoing up to a maximum value of vertical force (pounds) on the exhaust connection (including pressure loading) of 15-1/2 times the exhaust area (square inches).

4. These values of allowable force and moment pertain to the turbine structure only. They do not pertain to the forces and moments in the connecting piping, flange, and flange bolting which should not exceed the allowable stress as defined by applicable codes and regulatory bodies.

Authorized Engineering Information 8-21-1979.

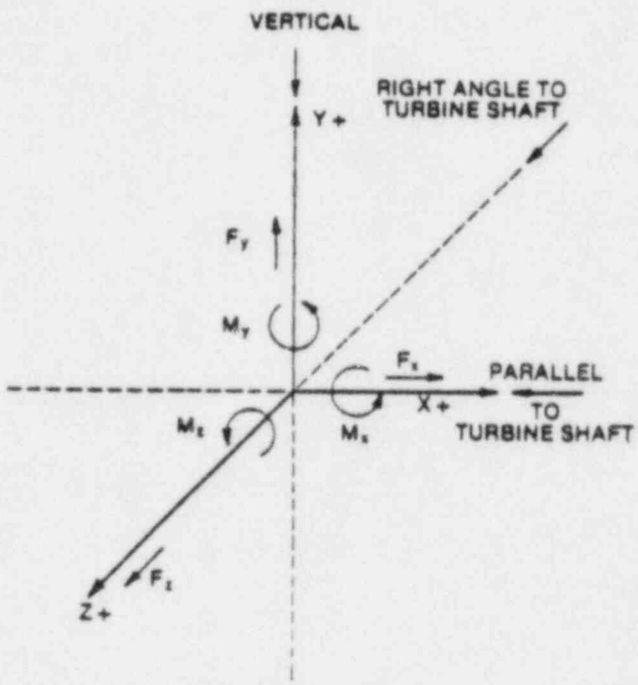
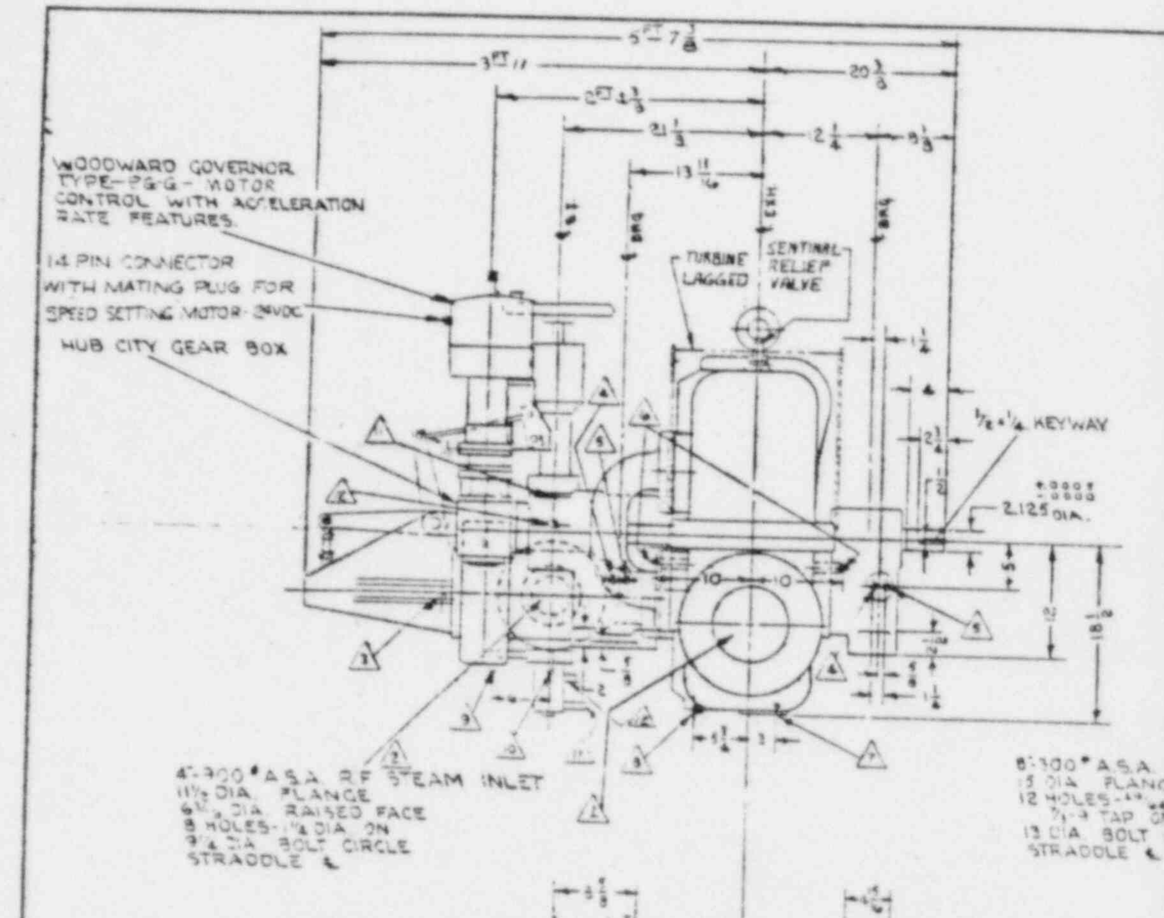
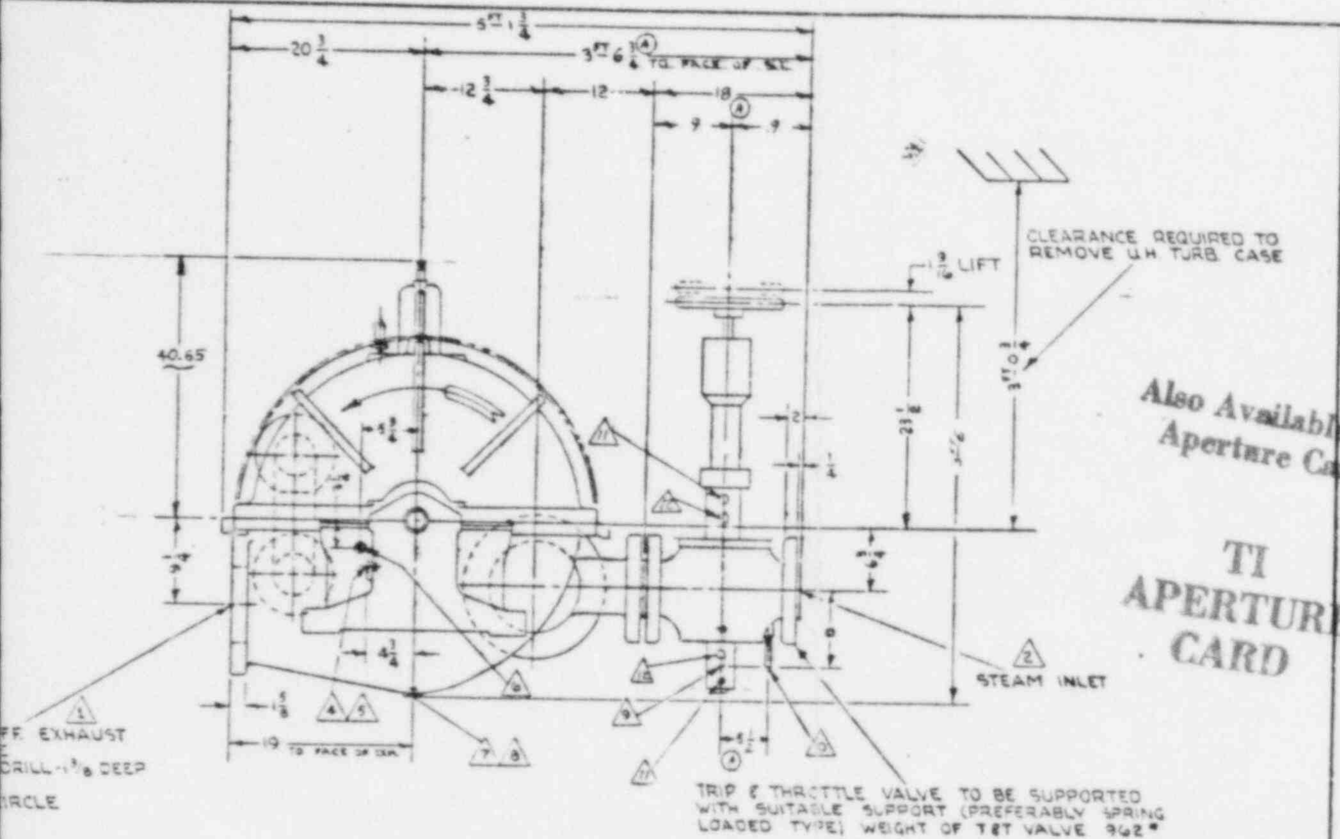


Fig. 8-13



WOODWARD GOVERNOR TYPE-PG-G- MOTOR CONTROL WITH ACCELERATION RATE FEATURES.
14 PIN CONNECTOR WITH MATING PLUG FOR SPEED SETTING MOTOR-24VDC
HUB CITY GEAR BOX
TURBINE LAGGED
SENTINAL RELIEF VALVE
KEYWAY
2.125 DIA.
4"-900# A.S.A. R.F. STEAM INLET
11½ DIA. FLANGE
6¼ DIA. RAISED FACE
8 HOLES-1⅛ DIA. ON
9¼ DIA. BOLT CIRCLE
STRADDLE ℄
8"-300# A.S.A.
13 DIA. BOLT
STRADDLE ℄
TURBINE
4-HOLES-1" DIA. FOR ⅞-9 BOLTS
4-HOLES-1⅛ DRILL & REAM TAPER PINS, FURNISHED
2-HOLES-1⅛ DRILL FOR 1" HOLD DOWN BOLTS
4-HOLES-1⅛ DRILL-⅞ TAP IN BASE FOR SPECIAL BOLTS & WASHERS BY TST CO. DO NOT CLAMP PEDESTAL TIGHT. CHECK FINAL ALIGNMENT. WASHERS HAVE BEEN MACHINED SO AS TO ALLOW .003 TO .005 BETWEEN PEDESTALS & WASHERS, AFTER BOLTS ARE TIGHTENED. WASHERS, BOLTS AND PADS HAVE BEEN STAMPED TO ASSURE PROPER ASSEM. DIMENSIONS FOR HOLD DOWN BOLT HOLES ARE APPROXIMATE... LOCATE HOLES IN BASE FROM THIS UNIT.
PLAN VIEW OF FEET
78748D



REV-

DWG. NO. 78748D/37686 AIS

CERTIFIED CORRECT FOR—
BYRON JACKSON PUMP DIV.
FOR
CLEVELAND ELECTRIC
DAVIS BESSE

ORDER NO. V-147411

PER

DATE

CUSTOMER'S CONNECTIONS				
ITEM NO.	NO. REQ.	SIZE	DESCRIPTION	
1	1	8-300# FLANGE	EXHAUST	VALVE
2	1	4-400# FLANGE	STEAM INLET	VALVE
3	1	1/2 NPT.	VALVE STEM LEAKOFF	NO VALVE
4	2	1/2 NPT.	COOLING WATER-INLET	NO VALVE
5	2	1/2 NPT.	COOLING WATER-OUTLET	NO VALVE
6	2	1/2 NPT.	GLAND DRAINS TO ATMOSPHERE	NO VALVE
7	1	3/4 NPT.	TURBINE CASING DRAIN	VALVE
8	1	1/2 NPT.	STEAM RING DRAIN	VALVE
9	1	1/4 SCH. 80 PIPE	BELOW SEAT DRAIN	VALVE
10	1	1/2 SCH. 80 PIPE	ABOVE SEAT DRAIN	VALVE
11	2	1/2 NPT.	LEAK-OFF CONN. - TO ATMOS. DRAIN - NO VALVE	
12	2	1/2 NPT	T&T VALVE STEM H.P. LEAKOFF - TO 30 PSIG HEADER	
			30 - 70 PSIG HEADER OR TURBINE EXHAUST HEADER	

FOLLOWING EXTRAS SUPPLIED BUT NOT SHOWN

2 THERMOCOUPLES-PACK PAD
2 VIBRATION PROBES (ONE ON EACH BRG CAP)

FOR *BPEW. BY T.S.T. CO.

FILE # 37686 AEB

TYPE-GS-2

OUTLINE

SCALE 1 1/2 = 1 FT. DATE 5-18-72

THE TERRY STEAM TURBINE CO.
WINDSOR, CONN. U.S.A.

DRAWN
TRACED
CHECKED
APPROVED

TURBINE WGT. 2800#
T.&T. VALVE WGT. 962#

78748D

REF DWG. 77347D

8507300306-01

PROCEDURE FOR ALIGNMENT OF TURBINES

TO DRIVEN EQUIPMENT BY REVERSE INDICATOR METHOD

GENERAL: This section establishes procedures for cold and hot alignment checks of turbine-driven equipment. Procedures are based upon use of a bracket-mounted dial indicator, alternately mounted on each shaft, which eliminates the necessity of obtaining coupling hub face readings.

1. SCOPE - These procedures are applicable to alignment of driver and driven equipment where both shafts can turn as one, and where parallel offset and/or angular misalignment are present.

2. TYPES OF MISALIGNMENT - There are three conditions of misalignment which may exist.

   2.1 Parallel Offset. Shaft centerlines are parallel but slightly displaced with respect to each other as shown in Figure 1 (b).

   2.2 Angular Misalignment. Faces of shaft ends are at an angle with respect to each other, with shaft centerlines intersecting at one point, as shown in Figure 1 (c).

   2.3 Combination Offset and Angular Misalignment. Shaft centerlines are offset, and are not parallel with respect to each other as shown in Figure 1 (d).

3. FACTORS AFFECTING ALIGNMENT - The following factors must be considered during cold and/or hot alignment checks.

   3.1 Thermal Expansion Turbine, gear and/or driven equipment may rise vertically at their horizontal centerlines, and may also move horizontally, due to thermal expansion.

      3.1.1 Initial cold alignment is based upon calculated thermal movement using theoretical linear thermal expansion coefficients.

(a) If shaft "A" is calculated to move vertically more than shaft "B" at normal operating and ambient temperatures, shaft "A" should be set lower than shaft "B" by the amount of calculated centerline rise, so that shaft centerlines will be line-to-line during normal steady-state operation.

(b) Linear thermal expansion may be found by the formula:

$$\overline{\Delta \ell} = \ell_o \kappa (\Delta \tau / 2)$$

where $\overline{\Delta \ell}$ ≡ expected average rise or movement, (in.)

ℓ_o ≡ initial distance or height between support feet and shaft center, unit cold, (in.)

κ ≡ coefficient of thermal expansion, (in./in. - ^oF)

$\Delta \tau$ ≡ temperature difference between ambient and operating conditions, (^oF)

(c) In general, L.P. - end of turbine will not rise as high as its H.P. - end, due to higher temperature of steam at inlet. Rise at both ends of turbine shaft should therefore be calculated, and any resulting angular misalignment accounted for during initial cold alignment. An exception to this occurs when turbine casing is centerline supported at its H.P. - end. In this case, L.P. - end could rise more than H.P. - end.

3.1.2 Horizontal movement of gears should also be taken into account.

3.2 Shaft End Clearance. Axial clearance between shaft ends shall be per coupling manufacturer's recommendations, and should be measured with shafts against their active thrust faces. Allowances for any axial expansion of shafts, as well as combined axial movement of gear and pinion thrust clearance and backlash, must be included in gap.

3.2.1 Use temporary spacer or shim stock to ensure proper gap is maintained during alignment.

3.3 Bearing Oil Film. Depending upon type of journal bearings installed, shafts will rise during operation due to lubricating oil film thickness. For sleeve-type bearings, shaft rise is generally taken to be equal to bearing radial clearance, whereas for tilting-pad type journal bearings, the rise is about 0.001-in, regardless of clearance.

3.4 Cleanliness of Feet and Pads. Since dirt and burrs act as shim stock when between feet and pads, it is essential that all dirt or burrs be removed from feet and pads prior to alignment.

3.5 External Forces. Stresses caused by piping, rigid conduit connections, etc. must be eliminated or reduced to acceptable levels prior to final alignment.

3.5.1 Initial cold alignment should be performed with piping disconnected. After initial alignment has been completed, piping can be connected while distortion is checked and measured with dial indicators on the coupling. This will allow observation of any movement of the shafts caused by stresses imposed by piping.

3.6 "Soft-Foot" Condition. All turbine support feet must be on same plane. Condition created when one foot is slightly higher or lower in elevation. This difference in elevation can be caused by a machining error in the turbine feet, support pads upon which the feet rest, or by spongy (soft) shims.

3.6.1 Can be corrected by adding or removing shims, or by using heavier shims beneath affected foot.

4. ALIGNMENT PROCEDURES.

4.1 Hub Runout Check. Prior to alignment check, record O.D. and face runout of coupling hubs to ensure roundness and concentricity with respect to shaft axis.

4.1.1 Set-up dial indicator to read on face of turbine coupling hub at a point nearest its outer circumference. Rotate turbine shaft and record maximum and minimum indicator readings. Face runout is given by diffference between maximum and minimum values.

4.1.2 Reposition dial indicator to read on O.D. of turbine coupling hub. Rotate turbine shaft and record maximum and minimum indicator readings. Roundness or O.D. runout, is given by one half the difference between these two readings.

4.1.3 Repeat steps 4.1.1 and 4.1.2 above for driven equipment coupling hub.

4.1.4 Position of maximum runout should be marked on both hubs prior to continuing alignment check. Readings obtained during alignment check must be corrected for O.D. runout.

4.1.5 Face or O.D. runout in excess of 0.0015-in. must be corrected by reinstalling hub and keys or by hub replacement as applicable.

4.1.6 Record runout values on Alignment Record Sheet, Figure 2.

4.2 Turbine-to-Driven Equipment Alignment. Secure a non-sagging indicator mounting bracket to turbine half coupling hub and set-up dial indicator to read on O.D. of half coupling hub of driven equipment, at same location that O.D. runout was obtained. Mark both hubs so that relative position of bracket and indicator can be maintained when reversed. With dynamically balanced couplings, align match marks and maintain in position during alignment check.

4.2.1 Set dial indicator zero at mid travel of stem. Most indicators read plus (+) when stem tip is pushed in towards dial, and minus (-) when tip moves away from dial.

4.2.2 Ensure dial indicator supports do not deflect. If sag occurs, record amount on Alignment record Sheet and correct readings accordingly. Ref. Figure 1 (e).

4.2.3 Rotate both hubs together and record indicator readings on Alignment Record Sheet at 12 o'clock vertical positions, and 3 o'clock and 9 o'clock horizontal positions.

(a) When rotating shafts, always use same direction of rotation using hands or a strap wrench. Do not use pipe wrenches.

(b) Algebraic sum of indicator readings taken at 12 o'clock and 6 o'clock must equal algebraic sum of 3 o'clock and 9 o'clock readings, within limits of hub runout. Use 12 o'clock position as "zero" starting point for all readings. When rotating shafts dial indicator should always return to its zero setting when at its starting point.

(c) Use a good mirror and adequate lighting to follow indicator during rotation.

(d) Take two or three sets of dial indicator readings to verify accuracy.

4.2.4 Make a graphical plot of indicator readings to show relative shaft positions, as shown in Figure 3. Parallel offset is one half the difference (T.I.R.) between two readings taken at 180^{o} from each other.

4.3 Driven Equipment-to-Turbine Alignment. Remount indicator bracket on driven equipment half coupling hub, and set-up dial indicator to read on O.D. of turbine half coupling hub at same location that O.D. runout was obtained. Repeat requirements of paragraph 4.2 and subparagraphs 4.2.1 through 4.2.4 above.

4.4 Use of Double Brackets. If available, two opposing bracket may be mounted at same time with respective dial indicators set-up to read on coupling hub O.D.'s as described above. This will allow quicker alignment checks to be made, as well as eliminate any possible setup errors during reversal of a single bracket.

4.4.1 When conditions are such that it is impossible to obtain satisfactory readings on coupling hubs, accurate readings may be obtained by use of two brackets, modified to include an indicator reading post on each bracket. Dial indicators are set to read on opposite indicator posts vice coupling hub. In this method, coupling hub sleeves can be secured together, and hence would be useful for hot-alignment checks as it would eliminate time delay in uncoupling the hubs.

4.5 BRACKET MANUFACTURE. Brackets must be accurately manufactured. It is important that support for dial indicator is parallel to longitudinal horizontal centerline axis of shaft, in order to obtain accurate readings.

Example: From thermal expansion considerations, etc., assume that it has been determined that for initial cold alignment, turbine must be set 15 mils below and 8 mils to the north of driven equipment. Initial reverse indicator readings are taken and results shown on Figure 3.

A. PILOT DISPLACEMENT - Since TIR for OD represents twice the displacement of shaft centerline, only half the value of the readings should be plotted. Graphically locating displacement versus linear dimensions of unit will reveal amount of shims or lateral displacement required to achieve desired alignment. Construct graph similiar to Figure 3, and establish plane of reference, such as centerline of driven unit, since turbine is being aligned to driven unit. At a position conveniently selected, construct centerline of driven unit as well as point along it which the turbine to driven unit readings were taken, (i.e. Plane A). For reference an extension of this centerline can be made throughout the length of the graph by using a dashed line. Determination of the value of each grid horizontally should be made at this point. Consulting the assumed dimensions of the turbine from Plane A to outboard foot as shown in Figure 3, sum is found to be 114 inches. The MINIMUM VALUE for each grid will result in maximum display of length of turbine, and also maximum accuracy. A value of 1 in./ division has been selected and Planes A,B,I.B.F & O.B.F. located on the basis of the turbines dimensions. This is the scaled down representation of the driver's length. A similar technique is used to determine the value of the vertical grids which will represent the displacement at the various points along the length. A value of 0.5 mils/division is selected for accuracy. Plotting Plane A first, will prevent confusion in plotting Plane B. Displacement a Plane A is -12, or the turbine is low to the driven unit in this plane. Locate a point 12 mils below the centerline of the driven unit. Displacement at Plane B, driven unit to driver is +8 or the driven unit is high to the turbine by 8 mils. Since the brackets were reversed, or different relationships were measured, the sign in reality changed. Connecting points #1 and #2 with a straight line that extends beyond Plane B will show the existing elevation of the turbine in relation to the existing elevation of the driven unit. Next, determine where in relation to driven unit centerline, should the turbine be located. In this example expected rise is assumed to be 15 mils, hence turbine must be set low to the driven unit by 15 mils. An additional line is constructed parallel to the extended driven unit centerline, but offset low 15 mils, using same vertical scale as before.

This is the desired elevation. Where the turbine is versus where is it desired to be is determined by comparing points #3 and #4 to where the desired centerline intersects with Planes IBF and OBF respectively. Point #3 is 9.5 mils high and point #4 is 23.5 mils high. These are the amounts of shims to be removed from under the inboard and outboard turbine feet respectively. Determining offset displacement is done in a similar fashion. Direction for this example is established based upon North in relation to the driven unit. Place the direction on the graph. Considering turbine to driven unit readings, the turbine is displaced to the North by 4 mils at Plane A. This value is plotted above the driven unit reference centerline, point #5, using same scale of 0.5 mils/division. Driven unit to turbine readings at Plane B reveal that the turbine is displaced to the North by 2 mils, point #6. Again connect points #5 and #6 to determine points #7 and #8. A roll of 8 mils of the turbine to the South is anticipated. The desired offset centerline is established and once again the displacement at the feet is established. The inboard feet, Plane IBF, should be moved to the North by 7.5 mils, the outboard feet, Plane OBF, to the North by 9.5 mils. The total correction required for the shim change and lateral move would be; Inboard Feet -9.5 and N 7.5, Outboard Feet -13.5 and N 9.5.

B. MAKE SHIM CHANGES - One Foot at a time, using dial indicators placed at Planes IFB and OFB, from base to turbine, in order to monitor lateral movement of turbine.

C. CONFIRM RESULTS OF SHIM AND LATERAL MOVE CHANGES - Always recheck alignment after making changes to ensure proper results.

TOLEDO EDISON COMMENT

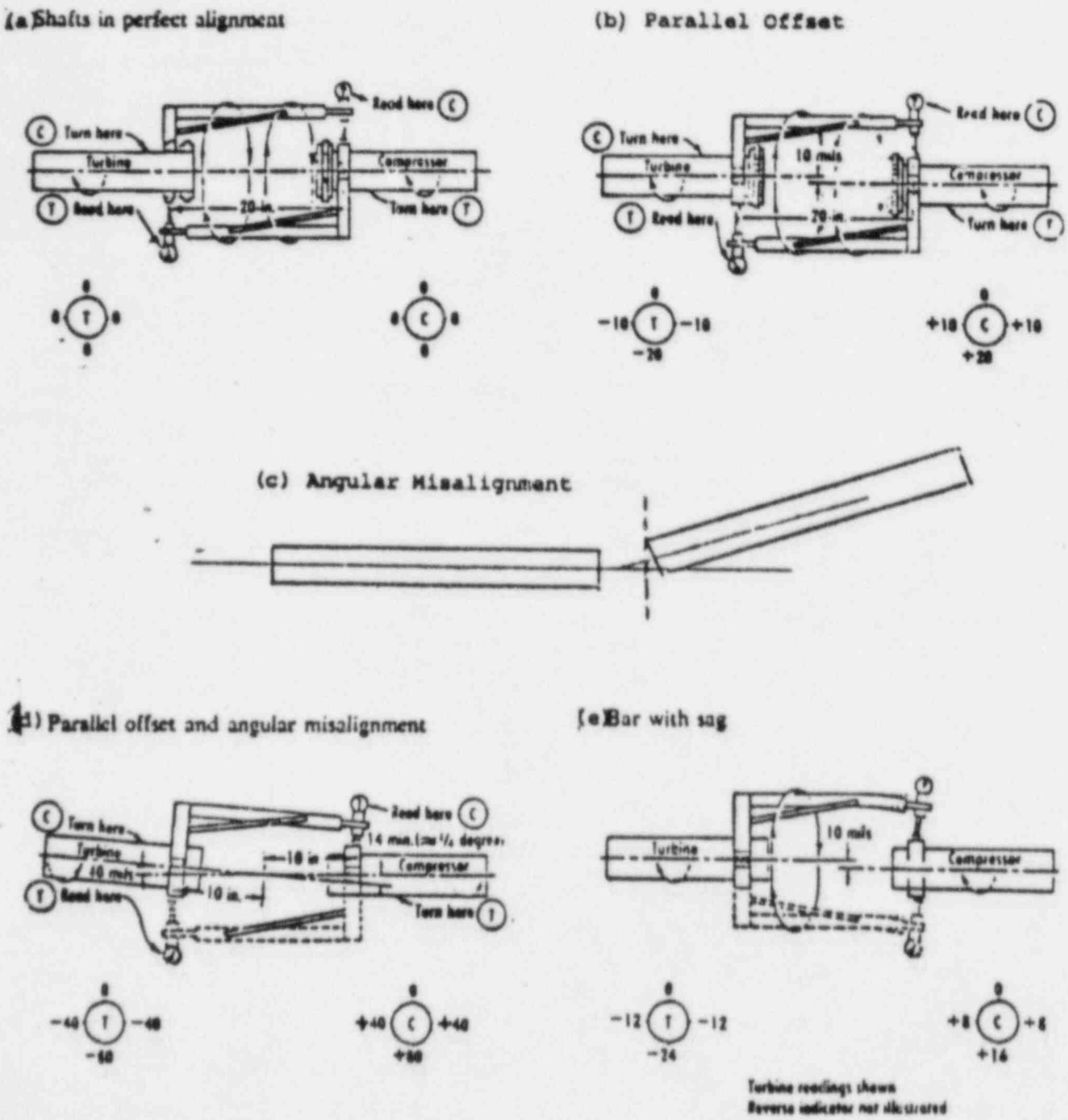


Figure 1. Illustration of Perfect Alignment, Types of Misalignment, and Support Bar Sag. (No horizonal offset assumed)

CUSTOMER ____________ ____________ USER ________________ LOCATION ________________

TURBINE TYPE ________ SER. NO. ________ GEAR TYPE ____________ SER. NO. ____________

OTHER UNIT TYPE ____________ SER. NO. ____________ MANUFACTURE ________________

H.S. COUPLING TYPE ________________ COUPLING GAP ________ DYN BAL ________

L.S. COUPLING TYPE ________________ COUPLING GAP ________ DYN BAL ________

THEORETICAL THERMAL GROWTH

TURBINE HORIZONTAL CENTERLINE RISE ____________ CASING SUPPORT ____________

GEAR HORIZONTAL CENTERLINE RISE ____________ HORIZONTAL OFFSET ____________

GEAR PINION BACKLASH ______ BULL GEAR END FLOAT ____________

OTHER UNIT HORIZONTAL CENTERLINE RISE ____________ CASING SUPPORT ____________

SHIM PACK TOTAL THICKNESS

UNDER TURBINE FACING COUP END: L.H. FOOT ____________ R.H. FOOT ____________

UNDER TURBINE FACING STEAM RING L.H. FOOT ____________ R.H. FOOT ____________

UNDER GEAR: BULL GEAR SIDE:TURBINE END ______ BLANK END ______ PINION SIDE ________

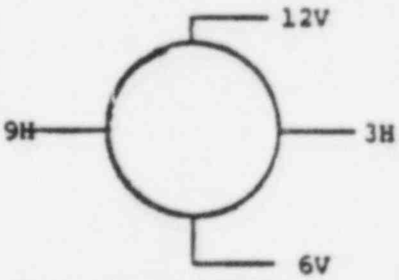
UNDER OTHER UNIT FACING DRIVEN END L.H. FOOT ____________ R.H. FOOT ____________

UNDER OTHER UNIT FACING FREE END L.H. FOOT ____________ R.H. FOOT ____________

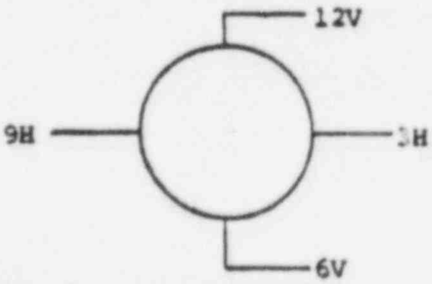
REVERSE INDICATOR READINGS (CORRECTED FOR SAG)

AMBIENT TEMP ° DIRECTION OF ROTATION OUTLINE DWG. NO.

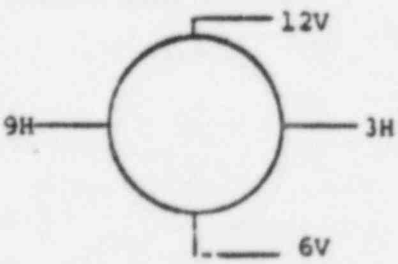
TURBINE AND PINION GEAR
FACING TURBINE H.S. COUP



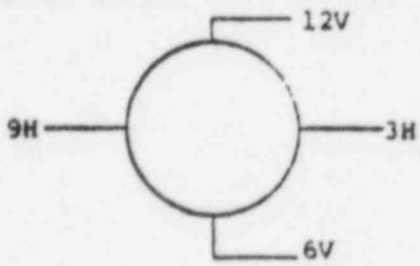
TURBINE AND PINION GEAR
FACING PINION GEAR H.S. COUP.



GEAR AND DRIVEN UNIT
FACING GEAR LS COUP.



GEAR AND DRIVEN UNIT
FACING DRIVEN UNIT LS COUP.



COUPLING RUNOUT

Turbine Hub ____ Face ___

Pinion Hub ____ Face ___

Gear Hub ____ Face ___

Driven Unit Hub ___ Face ___

Indicator Support

Bracket Sag(#1) ________

Bracket Sag(#2) ________

CHECKED BY ____________

DATE ____________

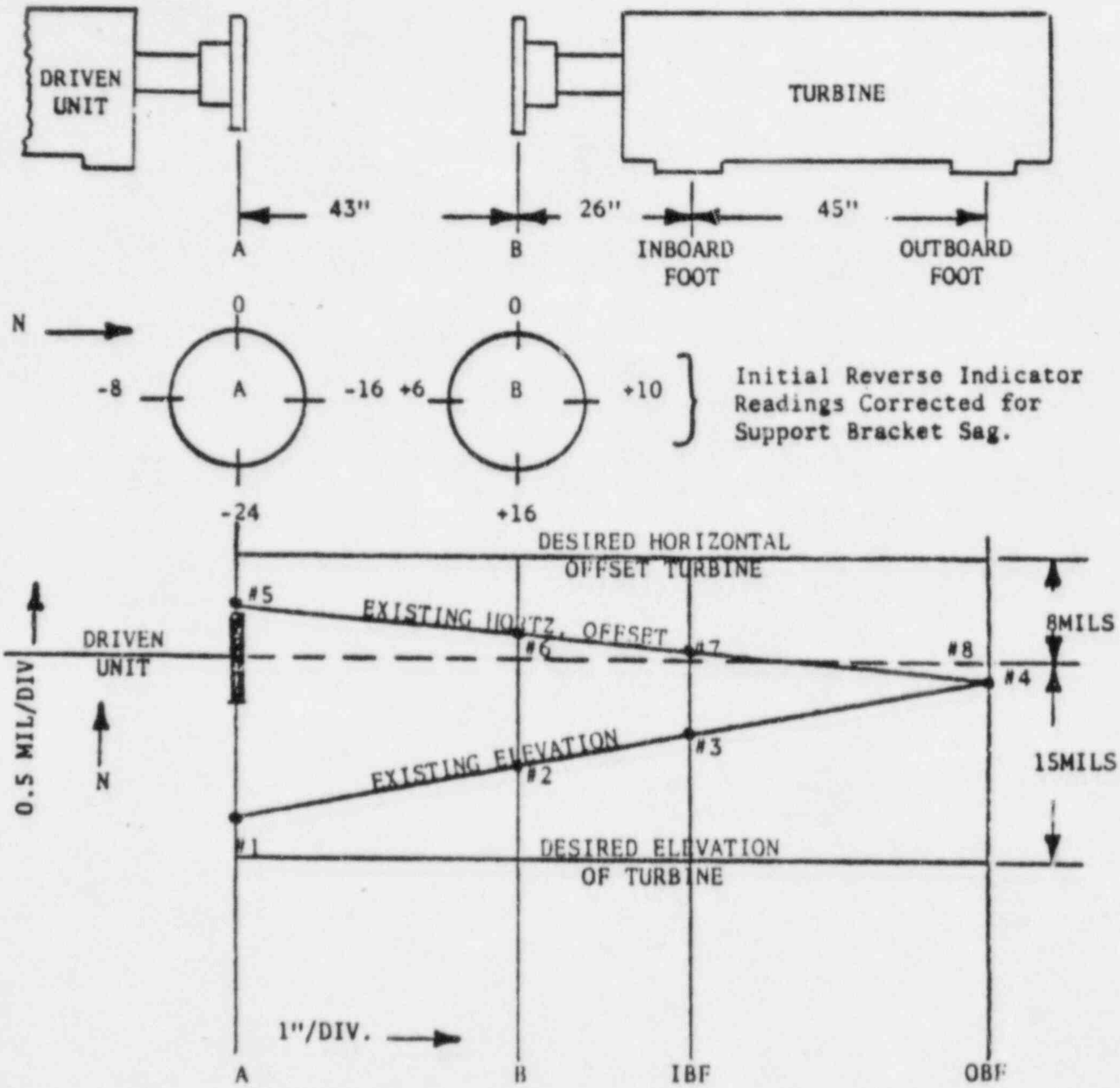


Figure 3. Sample Plot of Relative Shaft Positions

PARTS LIST

FILE: R1091N/F37686AB

TYPE: GS-2N

SECTION DRAWING NO. 128860E

SHT 1 OF 3

DWG NO. 128861A

ITEM NO.	NAME OF PART	TERRY PART NUMBER	MATERIAL TERRY SPEC	MATERIAL TYPE	MATERIAL GRADE	NO. PER UNIT
001	LEVER, TERMINAL SHAFT	88024B03		STEEL		1
002	LOCKWASHER SHAKEPROOF	75287A		STEEL		1
003	PIN, GOV. LEVER EXTENSION	59370	EM-31	ASTM:A276	S41000	1
004	END, HEIM ROD HFR-8	75208A15		STEEL/ UNIFLON		1
005	LOCKNUT, FLEXLOC 3/8-16	75233A06		STEEL		4
006	NUT, HEX. JAM R.H. 1/2-20	75324A07		STEEL		2
007	ROD, CONNECTING 1/2 Ø	65131	EM-124	ASTM:A108	G11170	1
008	NUT, HEX. JAM L.H. 1/2-20	75325A07		STEEL		1
009	END, HEIM ROD HFLR-8	75208A16		STEEL/ UNIFLON		1
010	WASHER PLAIN 1/2 Ø	75344A09		STEEL		2
011	LOCKNUT, FLEXLOC 1/2-13	75233A07		STEEL		1
012	PIN	112829B01	EM-31	ASTM:A276	S41000	1
013	SPRING, EXTENSION	32128	EM-122	ASTM:B221	6061-TG	1
014	BRACKET SPRING HOLDER	128726C01	EM-102	LC STEEL	COMM.	1
015	LEVER, GOVERNOR	128725C01	EM-102	LC STEEL	COMM.	1
016	STUD, SPRING	112830B	EM-124	ASTM:A108	G11170	1
017	NUT, HEX JAM 1/2-13	75266A05	EM-88	ASTM:A194	2H	2
018	GOVERNOR, WOODWARD PGG	128727A01	---	---	---	1
019	HUB CITY GEAR BOX	68216A01	---	---	---	1
020	SHAFT, VALVE LEVER	95760A		STN STL	410	1
021	1/4 x 1 1/2 LG. KEY	49337	EM-90	ASTM:A108	1018	2
022	WASHER, GARLOCK #DU20	75201A63		DU BRG. MATERIAL		2
023	PIN, LEVER PIVOT	92759B	EM-31	ASTM:A276	S41000	1

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TRACED
CHECKED WEL
APPROVED CAW 5-31-84

MF4

DWG NO 128861A SHT 1 OF 3

PARTS LIST

FILE: R1091N/F37686AB

TYPE: GS-2N

SECTION DRAWING NO. 128860E

ITEM NO.	NAME OF PART	TERRY PART NUMBER	MATERIAL TERRY SPEC	MATERIAL TYPE	MATERIAL GRADE	NO PER UNIT
024	NUT, HEX JAM 1/2-13	75266A05	EM-88	ASTM:A194	2H	4
025	SCREW, SOC. HD. CAP 1/4-20 x 1.00	94582A03	EM-87	ALLENOY COMM.	4037/4140	1
026	CRANK, CAM	94941D	EM-102	LC STEEL	COMM.	1
027	WASHER, GARLOCK DU-10	75201A56		DU BRG. MATERIAL		1
028	BUSHING, GARLOCK 12-DU-12	75201A26		DU BRG. MATERIAL		2
029	PIN, CRANK PIVOT	92760B	EM-31	ASTM:A276	S41000	1
030	SUPPORT, CAM CRANK	93271E	EM-102	LC STEEL	COMM.	1
031	END, HEIM ROD HF-8	75207A15		STEEL BRONZE		1
032	END, HEIM ROD HM-8	75209A15		STEEL BRONZE		1
033	BUSHING, GARLOCK 20-DU-12	75201A39		DU BRG. MATERIAL		3
034	LEVER, GOVERNOR	93296B	EM-102	LC STEEL	COMM.	1
035	PIN	63113	EM-31	ASTM:A276	S41000	1
036	STEM, VALVE	95923B	EM-59	MOD. ASTM:A276	S41000	1
037	GUIDE, UPPER VALVE STEM	95757A	EM-31	ASTM:A276	S41000	1
038	BUSHING,VALVE STEM CONN.	95759A	EM-31	ASTM:A276	S41000	1
039	CONNECTOR, VALVE STEM	95758A	EM-31	ASTM:A276	S41000	1
040	HEIM, SPHERICAL BRG. #LSS-8	75439A07		STEEL		1
041	GUIDE, LOWER VALVE STEM	95756A	EM-31	ASTM:A276	S41000	1
042	SCREW, SOC. HD. CAP 1/2-13 x 1.50	94584A05	EM-87	COMM.	4037/4140	4
043	BONNET, GOV. VALVE	90258D	EM-01	ASTM:A216	WCB	1
044	NUT, HEX. 1 1/8-7	75139A13	EM-88	ASTM:A194	2H	24
045	STUD BOLT 1 1/8-7 x 8.00	63120	EM-13	ASTM:A193	B7	10
046	STUD BOLT 1 1/8-7 x 8.50	66606	EM-13	ASTM:A193	B7	2

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TERRY

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DRAWN JS 5/16/84

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APPROVED [illegible] 5-21-84

MF4

DWG NO 128861A SHT 2 OF 3

PARTS LIST

FILE: R1091N/F37686AB

TYPE: GS-2N

SECTION DRAWING NO. 128860E

ITEM NO.	NAME OF PART	TERRY PART NUMBER	MATERIAL TERRY SPEC	MATERIAL TYPE	MATERIAL GRADE	NO. PER UNIT
047	BODY, COV. VALVE 4"-900#	91200D	EM-01	ASTM:A216	WCB	1
048	WASHER, GARLOCK DU12	75201A58		STEEL		1
049	WASHER, GARLOCK DU10	75201A56		STEEL		1
050	WASHER	106969A08		STEEL		2
051	PIN, TAPER #6 x 3.00 LG.	75108A34		STEEL		2
052	STUD BOLT 1"-8 GOV. VALVE BODY	13472	EM-13	ASTM:A193	B7	8
053	NUT, ALLEN 1"-8	75176A11	EM-87	ALLENOY COMM.	4037/4140	8
054	GASKET, R-1 15P FLEX	75286A02		STN STL		1
055	GASKET R-1 15L FLEX	75286A01		STN STL		1
056	VALVE SEAT	79181C	EM-59	MOD. ASTM:A276	S41000	1
057	VALVE 3" VENTURI	90076D	EM-125	ASTM:A276	S44004	1
058	VALVE SLEEVE	79180C01	EM-50	SPRING WIRE	INCONEL 600	1
059	NUT, HEX 3/8-24	105564A		STEEL		1
060	BUSHING, GUIDE	79344A01	EM-125	ASTM:A276	S44004	2
061	SPACER, BONNET	64843		P-55 PUREBON		22
062	WASHER, FLAT	54846	EM-59	MOD. ASTM:A276	S41000	20
063	RING, TRUARC SNAP N-5000-112	75144A21		STEEL		2

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REV & ECN

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DRAWN JS 5/16/84
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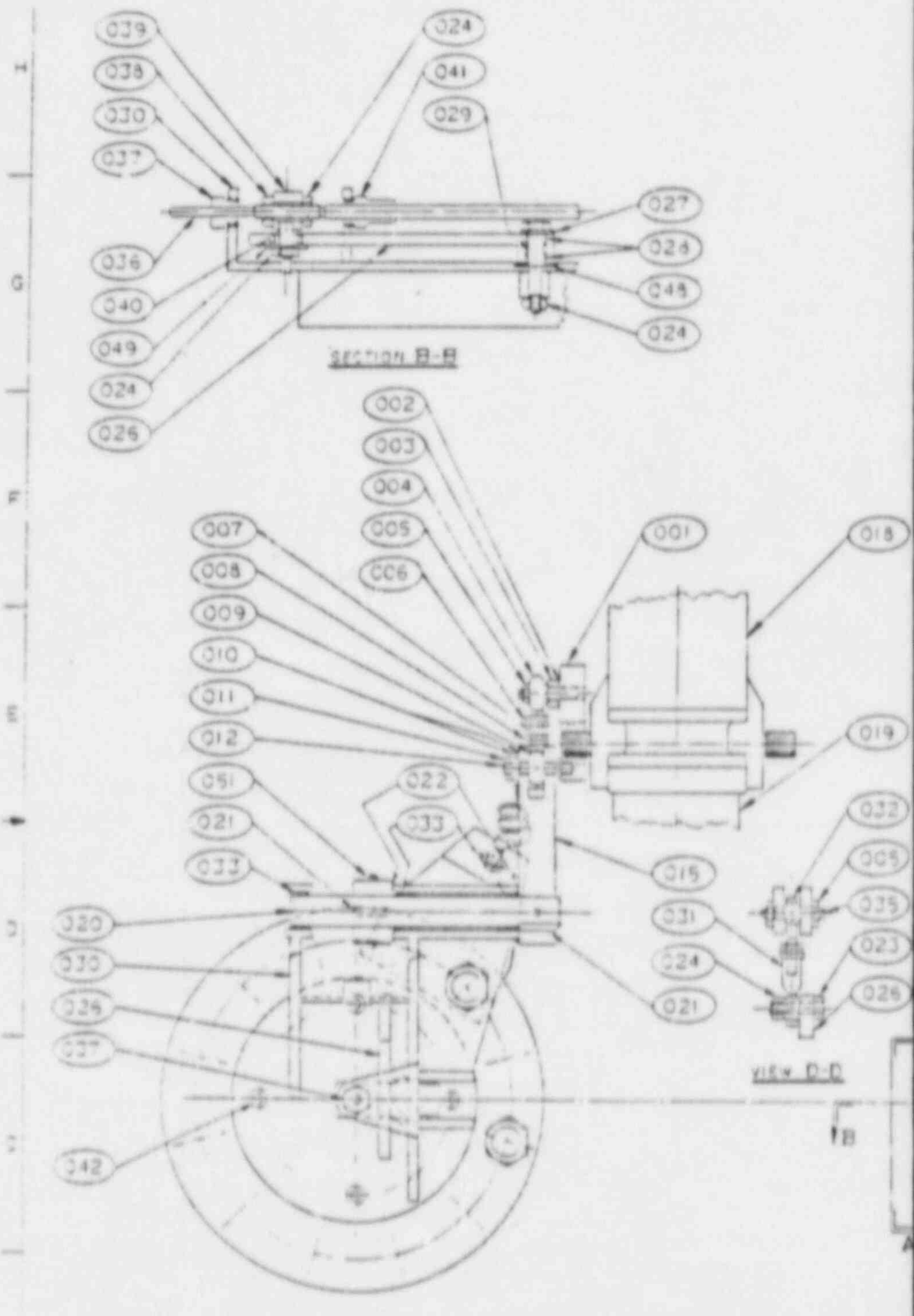
CHECKED WEL
APPROVED [signature] 5-21-84

MF4



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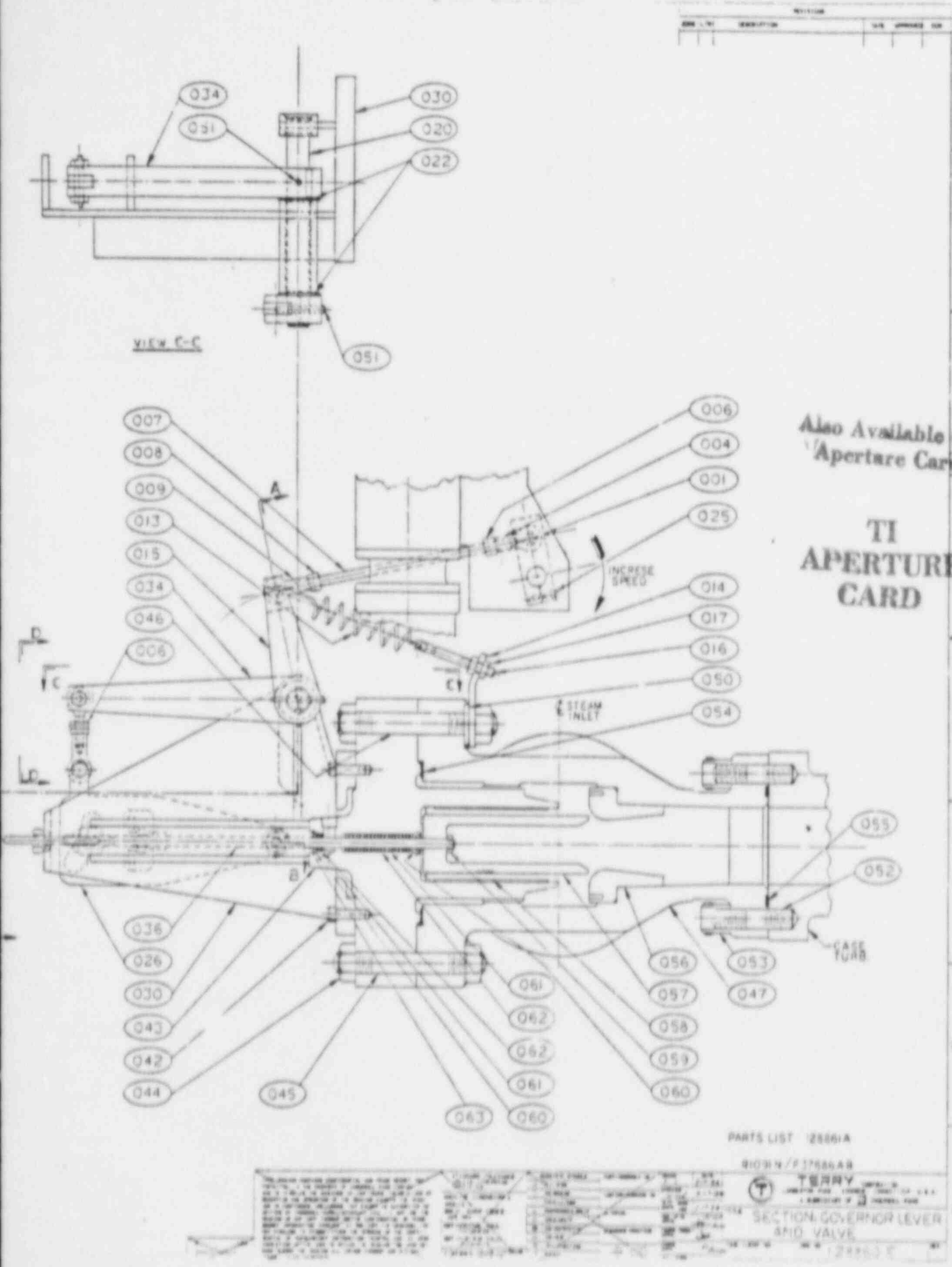

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8507300306-02

CONTROL SYSTEM

GOVERNOR (Woodward Type PGG)

The governor controls turbine speed by controlling the amount of steam supplied to the turbine. Speed control is isochronous, i.e., the governor will maintain constant turbine steady state speed, within the capacity of the unit, regardless of load.

GENERAL

The governor is of the mechanical hydraulic type, driven by the turbine rotor through spiral reduction gears.

The governor contains a gear type oil pump and reservior for supplying oil under pressure to the remote servo. Internal spring loaded accumulators maintain oil pressure and act as relief valves.

A spring loaded, mechanical flyweight head assembly, is driven via a rotating power cylinder assembly. Oil under constant pressure is maintained on the smallest surface area of the servo piston. Oil, acting on the largest surface area of the piston, is either under supply pressure, to drain or locked according to the position of the pilot valve.

The action of the servo is a "push-pull" motion. In this application, movement of the servo rod in an upwards direction causes a decrease in turbine speed, whereas, a downward movement will cause an increase in speed.

For more specific details of the governor operation and maintenance, refer to the Woodward Governor bulletins in this section.

The function of the governor is to sense and control turbine speed over a varying range, maintaining speed constant with varying load for any setting. The governor is designed to meet the operating requirements of the installation as long as the load does not exceed design capacity.

The operating speed can be varied either by local manual setting or by varying a pneumatic signal to the governor from a remote control position.

NOTE:

Manual operation is not to be used in conjunction with pneumatic or vice versa.

SPECIAL GOVERNOR MECHANISM FEATURES

GENERAL

The speed at which the governor will control is determined by the force exerted on the toes of the flyweights by the speeder spring in the basic governor section. Speeder spring force is determined by the position of the piston in the speed setting cylinder. The position of the piston, in turn, is determined by the volume of oil trapped in the area above the piston. The direction and rate of oil flow into or out of this area is controlled by the speed setting pilot valve plunger with is mechanically linked to the bellows. If the plunger is moved downward, uncovering the upper edge of a metering port in the bushing, pressure oil is allowed to flow into the speed setting cylinder. This displaces the piston downward, further increasing speeder spring tension and thus increasing the speed setting. If the plunger is moved upward uncovering the lower edge of the metering port, oil is permitted to drain from the cylinder. This allows the piston spring to raise the piston, decreasing speeder spring force and thus lowering the spring setting.

ACCELERATION CONTROL

The rate of movement of the speed setting piston over its full downward strike (idle to maximum speed) is usually retarded to occur over some specific time interval. This is done by admitting governor pressure oil into the rotating bushing through an orifice which registers with the main supply port once in every revolution of the bushing. This reduces the rate at which oil is supplied to the control port in the bushing and thus, the rate of oil flow to the speed setting cylinder. The diameter of the orifice determines the specific time interval which may be anywhere within a nominal range of 1 to 50 seconds. Thus the rate at which the speed setting may be increased is restricted under all conditions of operation. The longer rates are generally used with turbo-supercharge units to permit the supercharger to accelerate with the engine.

CONTROL SYSTEM CONTINUED....

The rate of movement of the power piston over its full upward stroke (maximum to idle speed) is also restricted on turbo-supercharged units to prevent compressor surge during decelerations. This timing may be anywhere within a nominal range of 1 to 15 seconds. In these cases, the speed setting pilot valve plunger has an additional land (not illustrated) which covers the drain port in the bushing. A vertical slot in the drain land registers with a second orifice in the rotating bushing once each revolution. This restricts the rate at which the oil is allowed to drain from the speed setting cylinder. The width of the slot in the drain land determines the length of tine the drain port (orifice) is open during each revolution and thus the specific deceleration time interval.

This particular unit is supplied with a 30 second acceleration bushing.

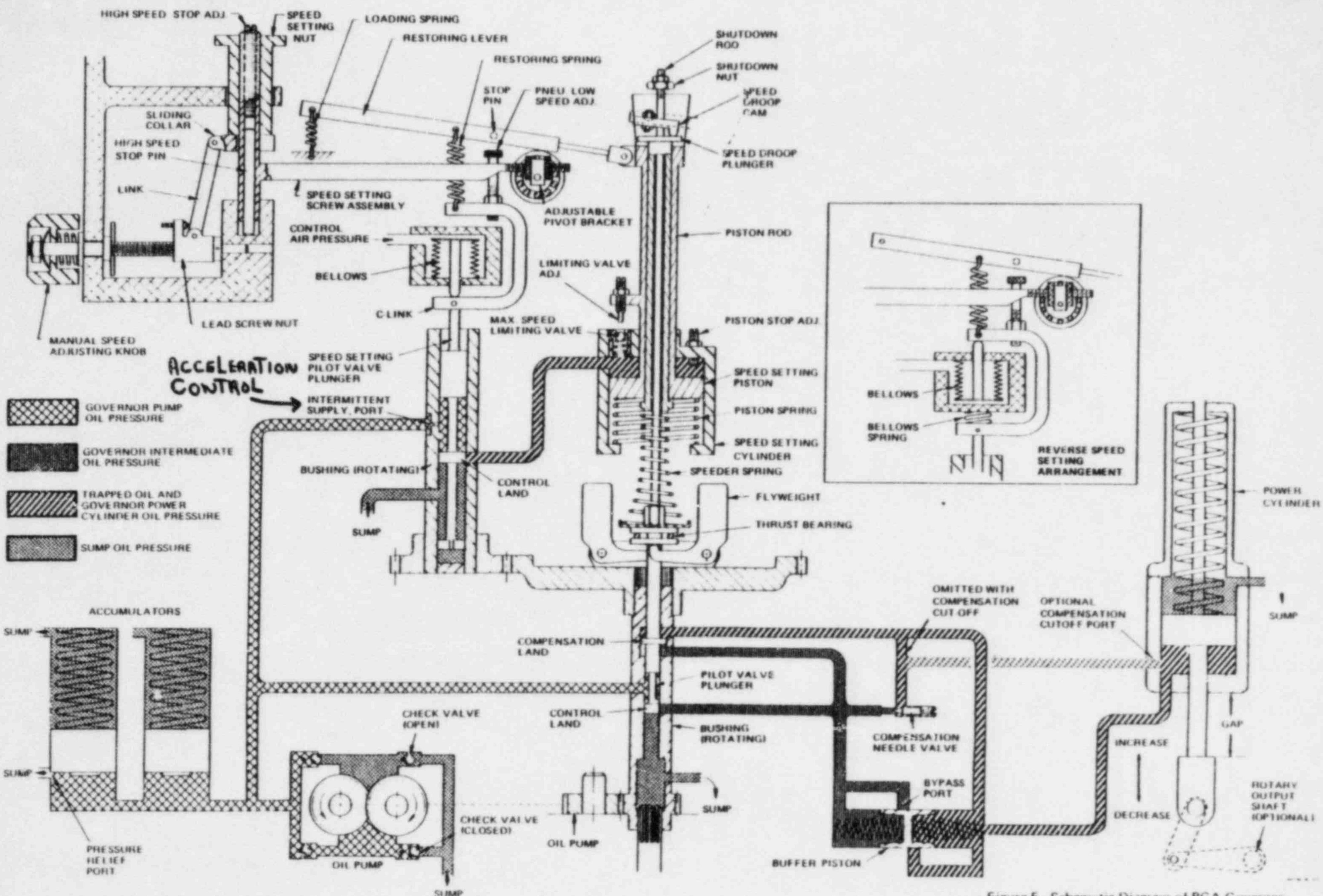
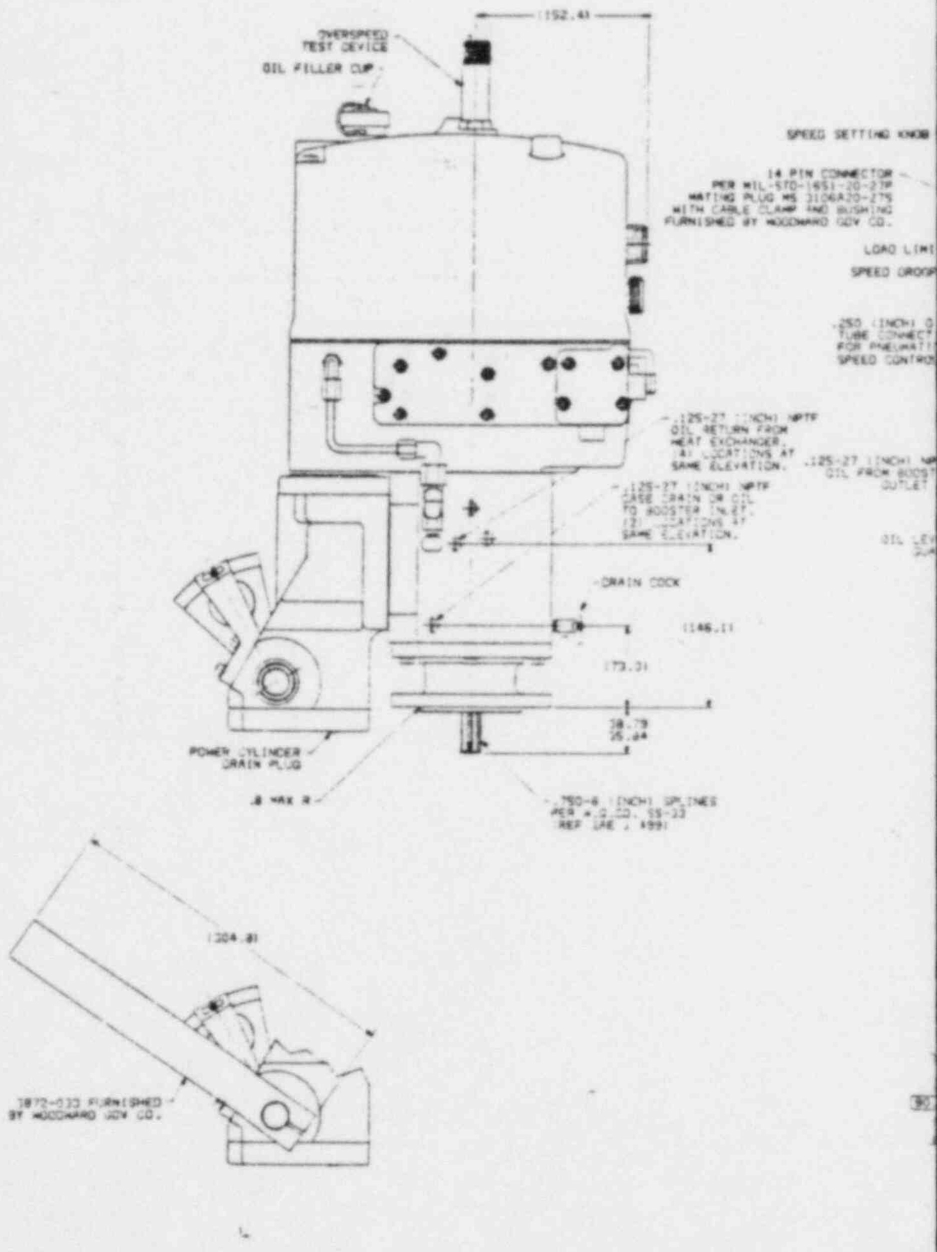


Figure 5. Schematic Diagram of PGA Governor (Bellows Direct and Reverse Speed Setting)



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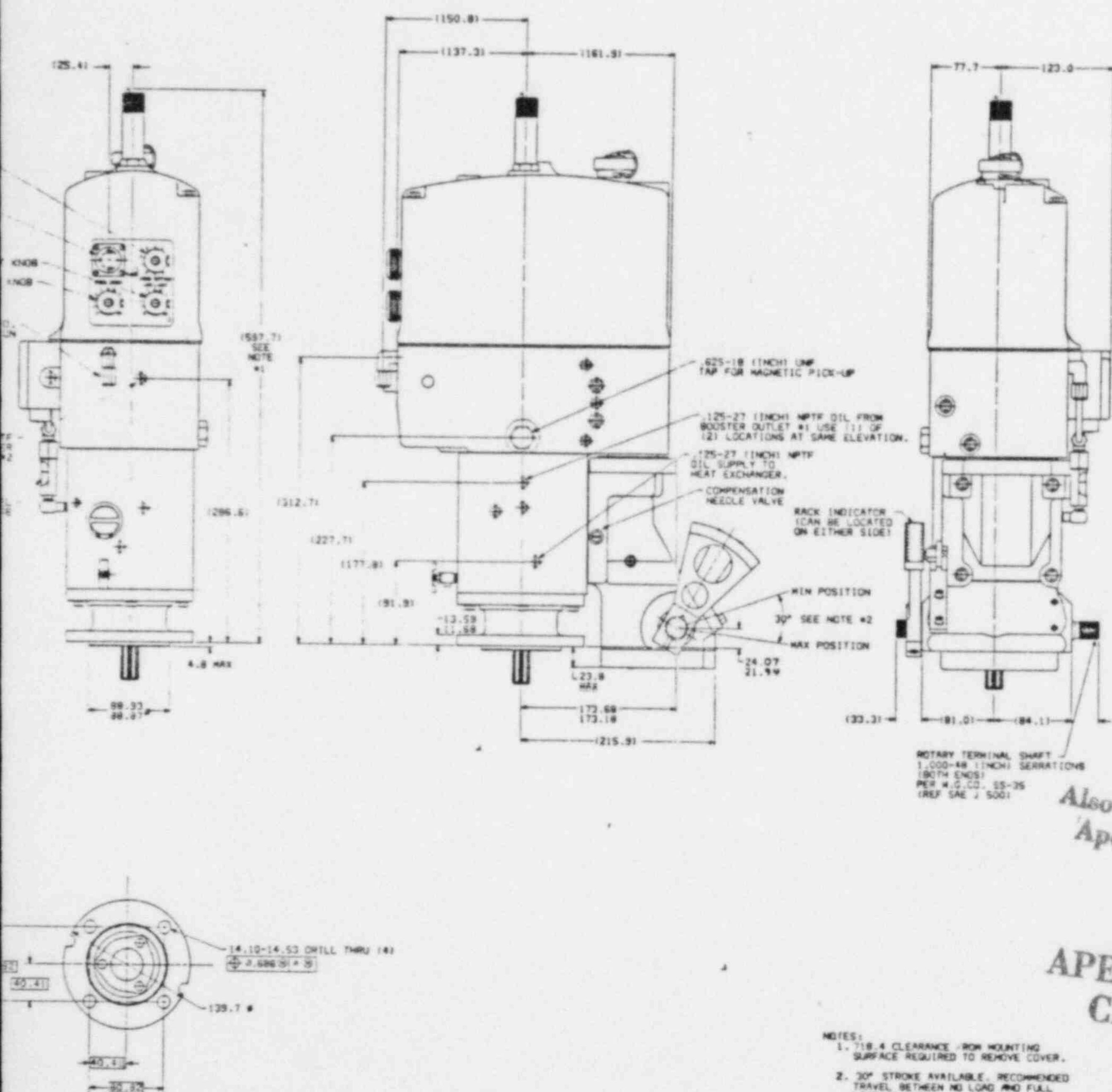

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NOTES:

1. 718.4 CLEARANCE FROM MOUNTING SURFACE REQUIRED TO REMOVE COVER.
2. 30° STROKE AVAILABLE. RECOMMENDED TRAVEL BETWEEN NO LOAD AND FULL LOAD IS 20°.
3. 9903-206 OPERATES AT 200 PSI. THIS INCREASES SERVO OUTPUT TO 58 FT-LBS.

METRIC

THIS IS AN OUTLINE DWG OF 9903-206.

THIRD ANGLE PROJECTION

WOODWARD GOVERNOR COMPANY

GOV. OUTLINE- OF PGG (W/29 FT-LB ROTARY SERVO & PG ROUND BASE)

SIZE E | CODE IDENT NO 31761 | 9988-474

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