L-33 TEST
Version 20020301
(Formerly CRC L-33 Test and FTMS 791B Method 5326.1)

1. SCOPE

1.1 This standard describes a test procedure for evaluating the rust and corrosion inhibiting properties of a gear lubricant while subjected to water contamination and elevated temperature in a bench-mounted hypoid differential housing assembly. It may be referred to as the L-33 test.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see Annex A1.

1.3 The values for temperature stated as °F, for pressure stated as psi, and volume stated as fl oz are to be regarded as standard. The SI values given in the parenthesis are provided for informational purposes only.

2. REFERENCED DOCUMENTS

2.1 *ASTM Documents:*

STP 512-A Laboratory Performance Tests for Automotive Gear Lubricants Intended for API GL-5 Service [1]

2.2 *Society of Automotive Engineers Standards:*

J308 Axle and Transmission Lubricants [2]
J923 Axle Nomenclature and Terminology [2]

2.3 *Coordinating Research Council Manuals:*

Manual No. 21 Gear, Bearing & Seal [3]

2.4 *U.S. Military Specification:*

MIL-PRF-2105E Lubricating Oil, Gear, General Multipurpose [4]
MIL-P-3420F NOx-RUST Paper [4]

2.5 *Dana Spicer Publication:*

Bulletin No. 5304-2, Maintenance Manual Spicer Model 30 [5]

3. Terminology

3.1 Descriptions of Terms Used in This Standard

3.1.1 *Corrosion*, n--an alteration of a finished metal surface by discoloration, accompanied by roughening not attributable to mechanical action.

3.1.1.1 *Rust*, n - a special case of corrosion, which always deteriorates or alters the original surface condition.

Discussion - rust always has color (usually, but not limited to red, yellow, brown, black) and one of the following descriptive characteristics: *Depth*: the rusted surface is built up relative to that of adjacent areas. *Texture*: the surface may appear to be etched, scaly or otherwise visibly different than adjacent areas.

3.1.1.2 *Stain*, n - a surface modification that is attributable to discoloration only.

3.1.2 *Downtime*, n--an interruption of power to the test unit for a period greater than 10 seconds.

4. Summary of Test Method

4.1 This procedure utilizes a Dana Corporation Model 30 hypoid differential assembly, Part No. 27770–1X, 4.10 ratio, standard differential with uncoated ring and pinion, without axle tubes[5].

4.2 *Test Unit Preparation*

Prior to each test, the new differential housing assembly is completely disassembled and cleaned. The axle spacer block is discarded and all rated parts (except bearings and cups) are abrasive blasted. All bearings must be disassembled from their mating parts prior to abrasive blasting. All internal parts and rated surfaces are then coated with test oil, and the unit reassembled. It is then installed on the motoring rig; next, an oil temperature monitoring probe and a drive shaft are connected, then a cooling fan and heat lamps are placed into position near the test unit.

4.3 *Motoring Phase*

The test unit is charged with 40 fl oz (1.2 L) of test oil, then driven by an electric motor at 2500 r/min pinion speed in an unloaded condition (no axle shafts are used for the test). Next, 1 fl oz (30 ml) of specified test water is added and the pressure relief system, set to 1 psi (7 kPa) is installed in the oil fill opening (all other test unit openings are already sealed). When the lubricant temperature reaches 180°F (82.2°C) the relief system is plugged and the motoring phase continues for four hours at this controlled temperature.

4.4 *Storage Phase*

At the completion of the motoring phase the motor is stopped. The test unit is removed from the motoring rig and placed in a storage box at 125°F (52°C) for 162 h.

Note 1: A test with a shortened storage phase of only 18 h (special one-day test) has been used as a screening test.

4.5 *Inspection*

At the end of the storage phase, the test is complete. The differential assembly is then drained, disassembled and rated for rust, stain, and other deposits.

5. SIGNIFICANCE AND USE

5.1 This test simulates a type of severe field service in which corrosion-promoting moisture in the form of condensed water vapor accumulates in the axle assembly. This may happen as a result of volume expansion and contraction of the axle lubricant and the accompanied "breathing in" of moisture-laden air through the axle vent. The test screens lubricants for their ability to prevent the expected corrosion.

5.2 This test method is used or referred to in the following documents:

5.2.1 ASTM Publication STP-512A - Laboratory Performance Tests for Automotive Gear Lubricants Intended for API GL-5 Service [1].

5.2.2 SAE J308 - Information Report on Axle and Manual Transmission Lubricants [2].

5.2.3 U.S. Military Specification MIL-PRF-2105E Lubricating Oil, Gear Multipurpose [4].

5.2.4 SAE J2360 – Lubricating Oil, Gear Multipurpose (Metric) Military Use [2]

6. APPARATUS

6.1 *Laboratory Ambient Conditions*

6.1.1 *Test Operating Area*—The ambient laboratory atmosphere shall be free of dirt, dust, and other contaminants as required by good laboratory standards.

6.1.2 *Parts Cleaning and Abrasive Blasting Areas*—Adequate ventilation shall be provided in areas where solvents are used. Provide adequate safety equipment for abrasive blasting operations.

CAUTION—Combustible, vapor harmful

6.1.3 *Build-up Area*—It is recommended that the atmosphere in the test unit build-up area be filtered and maintained at uniform temperature and low humidity to prevent accumulation of dirt or rust on test parts. Otherwise it shall conform to requirements of 6.1.1.

6.1.4 *Parts Rating Area*—The rating of all test parts is conducted under conditions as defined in CRC Manual 21 [3].

6.2 *Motoring Rig, Test Unit and Laboratory Equipment*

6.2.1 *Test Unit Configuration*—The differential housing assembly is mounted on the motoring rig so that the housing cover attaching face is in the vertical plane; and at a height that allows the temperature sensing probe to be located in the bottom of the housing. Elements of the motoring rig design are shown in Figures 1 through 4.

6.2.2 *Drive System*--The drive system design is not precisely specified; however, the following equipment or its equivalent has been found to be suitable to turn the drive pinion at the specified 2500±25 r/min:

CAUTION— Rotating test stand equipment presents a physical hazard and safety guards shall be used.

U.S. Motors 1.5 hp (1.1 kW) electric motor, enclosed, 3600 r/min, 0.87 in. (2.22 cm) diameter shaft. [6]

Slide Motor Base, "Dyn-Adjust" No. 20-C. [6]

Dodge "Taper Lock" pulleys No. 40L100 (Driven) and #28L100 (Drive). [6]

Dodge "Timing" Belt No. 480L100. [6]

Additional components such as shafts, couplings, and bearing blocks are also necessary to connect the above components to drive the carrier pinion, but are left to the option of the testing laboratory.

6.2.3 *Vapor Pressure Control System*—The internal vapor pressure of the unit is controlled during the warm-up portion of the motoring phase by a specified water column pressure relief system set for 1.0± 0.1 psi (7 ± 0.7 kPa) connected to the housing cover with an appropriately sized NPT stainless steel 90^{O} street ell and a stainless steel full port valve. The system shall contain an oil trap and return vessel to return test oil to the unit in case of foaming, and a water trap and return vessel to prevent column water from moving back to test unit. The example set up in Fig. 1 has shown to be acceptable.

6.2.4 *Housing Cover Gasket*—Replace the factory supplied gasket with a single Teflon gasket for every test.[7]

6.2.5 *Housing Axle Tube Opening Seals*—Since the differential is tested without axle shafts or axle tubes, the housing openings shall be sealed. Fig. 2 shows an example of construction dimensions for fabricating a pair of seals to be installed in the axle housing openings before introducing test oil prior to starting the test.

6.2.6 *Temperature Control System, Motoring Phase*—During the motoring phase, the bulk oil temperature is sensed by an RTD or thermocouple (J or K type). The controller switches on a pair of 250 watt lamps and/or cooling fan which are directed toward the differential as needed to control bulk oil temperature at 180±1°F (82±6°C). A household-type electric fan having 12.0 in. (31 cm) diameter blades has been shown to provide acceptable cooling capability. Fig. 3 shows an example of the location of the heat lamp pair and the cooling fan. Fig. 4 shows the location of the temperature sensor in the differential housing.

6.2.7 *Storage Box and Temperature Control System, Storage Phase*—During the storage phase of the test, a double-walled aluminum or stainless steel box covers the differential housing assembly, and the bulk oil temperature is controlled at 125±1°F (52±6°C). An RTD or thermocouple (J or K type) in conjunction with the controller regulates heat input from four strip heaters giving a total output of 500 watts. A small fan electric motor of 115 VAC, 1550 r/min, turns a fabricated impeller to provide air circulation within the box. Fig. 5 shows details of the impeller. Fig. 6 shows construction and electrical details of this box.

Note 2: Insulation on the outside surface of the box only may be necessary to maintain test temperature specifications.

6.2.8 *Abrasive blasting*—Blast the entire differential case, ring, pinion, side gears, differential pinion gears (spider gears), all four thrust washers and the inside surface of the differential housing cover plate with 80 grit aluminum oxide so as to remove pre-existing corrosion and produce a uniform surface. Do not abrasive blast the bearings, bearing cups and differential shaft (cross shaft pin).

6.2.9 The following specifies the abrasive blasting equipment and material:

Abrasive Blasting Cabinet:

Is to be used solely for cleaning L-33 test units.
Grainger Econo-Line 36” X 24”, Grainger Item # 3Z850
Measure air pressure for the blasting gun at the regulator just prior to entering the cabinet enclosure. Set the regulator to maintain 80 psig while flowing abrasive material.

Dust Collector:

Grainger Econo-Line 1000cfm, Grainger Item # 3JR93

Blasting Gun Setup:

Grainger Econo-Line 12 cfm Gun Assembly, Grainger Item # 3JT01
Grainger Econo-Line tungsten carbide Nozzle Tip ¼ inch I.D.
Grainger Item #3JT08, Change after fifteen L-33 units are blasted.
Grainger Econo-Line Air Jet 12 cfm, Grainger Item # 3JT04

Abrasive Blasting Material:

Alodur Fused Brown Aluminum Oxide [7]
80 grit – ANSI Table 3 Grade
Change the entire cabinet supply of abrasive blasting material after fifteen L-33 units are blasted.

CAUTION—Abrasive blasting presents a physical hazard; equipment manufacturer's precautions shall be consulted and followed.

7. REAGENTS AND MATERIALS

7.1 *Specified Test Water*—Fisher Scientific de-ionized ultra filtered water, Part number W2-4 or W2-20.

7.2 *Hydrocarbon Solvent*--Any hydrocarbon liquid with a flashpoint of 105 to 150 °F that will evaporate at ambient temperature without leaving a visible residue. Hydrocarbon solvents known to contain chlorine, fluorine, or Bromine shall not be used.

CAUTION—Combustible. Vapor harmful. See Annex A1.

7.3 *Rust Prevention Oil—Mobil Arma 245* [10]

CAUTION—Combustible mixture. Harmful or fatal if swallowed. See Annex A1.

7.4 *Build-up Lubricant*--Test oil will be used in all cases for test unit build-up.

8. TEST OIL

8.1 1.0 gal (3.7 L) is required for each test. The housing capacity is 2.5 pt (1.2 L); the remaining oil is used for coating the test parts during assembly.

9. PREPARATION OF APPARATUS

9.1 *Test Unit Preparation*

9.1.1 *Cleaning of Reused Fittings, Seals, etc.*--Clean, as necessary, all reusable parts including: axle tube opening seals, pressure relief system and elbow, and the temperature sensor and its fittings.

9.2 *Differential Assembly Build-Up*

9.2.1 *Cleaning and Preparation of Parts*

9.2.1.1 *Disassembly*—Completely disassemble the differential housing assembly and remove all parts from the differential case. The axle spacer block is discarded and not to be used in the build-up of the test axle. All bearings shall be disassembled from their mating parts.

9.2.1.2 *Differential Housing Modification*— Drill and tap the housing to

accept the temperature sensor using the test fixture shown in Fig 12 and Fig. 13. Install the temperature sensor so that the tip of the sensor is 1 ± 0.25 inches from the floor of the differential housing as shown in Fig. 4.

9.2.1.3 *Cleaning*— Pressure wash the differential housing and each individual component with hydrocarbon solvent using a round plastic bristle brush. Rinse the differential housing and each individual component with hydrocarbon solvent and dry with compressed air or nitrogen. The use of wire brushes and/or abrasive cleaning pads to clean the differential housing and individual components are not allowed.

CAUTION—Combustible. Vapor harmful. See Annex A-1.

Be sure that all grease and/or oil used in manufacturer's assembly is removed from bearings and wipe clean lip seals with a dry cloth.

CAUTION—Combustible. Vapor harmful. See Annex A-1.

9.2.1.4 *Functional Surface and Cover Plate Preparation* — Abrasive blast the entire differential case, ring, pinion, side gears, differential pinion gears (spider gears), all four thrust washers and the inside surface of the housing cover plate by uniformly abrasive blasting with 80 grit aluminum oxide. Do not abrasive blast the bearings, bearing cups and differential shaft (cross shaft pin). **Do not touch any cleaned surface with bare hands as moisture can cause rusting**.

After abrasive blasting and pre-test inspection (Section 9.2.1.5), pressure wash abrasive blasted parts, all four bearings, and bearing cups with hydrocarbon solvent and a round plastic bristle brush (Pressure not to exceed 30 psi). After pressure washing, rinse with hydrocarbon solvent and dry with filtered compressed air or nitrogen (pressure not to exceed 30 psi). A Wilkerson filter, model M18-02-CH00 is required to filter the compressed air or nitrogen. A Wilkerson model MTP-96-646 is the required replacement element for the filter assembly. The use of wire brushes and/or abrasive cleaning pads to clean the abrasive blasted parts is not allowed. Do not spin dry the bearings with the compressed air or nitrogen. Only use blowguns without a safety bypass to air dry the parts. A Milton model S154 has been found to be acceptable.

CAUTION—Combustible. Vapor harmful. See Annex A-1.

CAUTION—Abrasive blasting presents a physical hazard; equipment manufacturer's precautions shall be consulted and followed.

9.2.1.5 *Pre-Test Inspection*—After the parts have been abrasive blasted and before cleaning and rinsing; carefully inspect the abrasive blasted parts, bearings and bearing cups for rust or corrosion and damage. If

any rated area is found to have rust, re-prepare as described above in 9.2.1.4. If defects are found, such as casting flaws etc., which might be mistaken for rust at the end of test inspection, a notation of their pre-test existence is to be added to the test report. If any bearing is found to have rust or damage, replace it with a new one that is rust-free. Note that the end of test inspection and rating make no allowances for parts rusted before start of test.

9.2.1.6 *Test Oil Coating*—Immediately coat all abrasive blasted parts evenly with test oil after they have been cleaned, rinsed and dried. Immediately coat all four bearings, bearing cups and differential shaft (cross shaft pin) evenly with test oil after they have been cleaned and rinsed. (Bearings, bearing cups and differential shaft (cross shaft pin) are not abrasive blasted). Dipping the parts in test oil or pouring the test oil over the parts are acceptable methods. The use of brushes to coat the parts with test oil is not acceptable. **Do not touch any test parts with bare hands—fingerprints can cause rusting.**

9.2.1.6.1 Lightly coat all bolts with test oil prior to assembly of test axle.

9.2.1.7 All parts shall be cleaned, rinsed, dried, and coated with test oil within two hours after abrasive blasting.

9.2.2 *Assembly of Test Unit*

9.2.2.1 *Drive Pinion Shaft Installation*—Assemble the drive pinion shaft with its bearings and install it in the housing following the guidelines in Dana Bulletin No. 5304-2[5]. Torque pinion-nut to 160-200 lbf-ft not the values listed in Dana Bulletin 5304-2. Determine pinion turning torque. See Section 9.2.2.2 for break and turn specifications. Record the final break and turning torque on the test report Form 2 (Annex A3).

9.2.2.2 *Differential Case Installation*—Assemble the differential pinion, side gears, shafts and thrust washers, shims, bearings and caps in the differential case. Then install the differential case assembly in the differential housing. Measure break and turning torque; turn torque shall be 7 to 13 lbf-in.(0.8 to 1.5 N m) and break torque shall be 8 to 18 lbf-in.(1.4 to 2.0 N m) The torque may be adjusted by either case disassembly and adding or removing shims, or adjusting the pinion pre-load following the guidelines in Dana Bulletin No. 5304-2. Record final break and turning torque on the test report Form 2 (Annex A3).

9.2.2.2.1 After completion of the test axle build and before the cover plate installation, place the test axle in a vertical position with the yoke in the upward position. Place the cover in a vertical position. Allow the assembled test axle and cover plate to drain for a minimum of 10 minutes.

9.2.2.3 *Test Oil Addition*- Charge 40± 1 fl oz (1.20 ±.03 L) of test oil to the test unit.

9.2.2.4 *Cover Plate, Seals, Temperature Probe Installation*—Install the cover plate with a new Teflon gasket, pre-wetted with the test oil on both sides (see Section 6.2.4). A new Teflon cover plate gasket is required for every test. Torque the cover plate bolts to 20–25 ft-lbf. Insert the two axle tube opening seals (Fig. 2) until they touch the differential case bearings, then pull back approximately 1/8th inch. Tighten the seals and install the temperature probe using Teflon tape as per Fig. 4, Fig. 12 and Fig. 13. Install the NPT stainless steel 90^{O} street ell and stainless steel full port valve.

10. CALIBRATION

10.1 *Storage Box Calibration*

10.1.1 Reference oils for stand calibration are available from the ASTM Test Monitoring Center[8] (TMC). Laboratories wishing to calibrate storage boxes using these oils shall participate in the referencing and storage box calibration program administered for this test by the TMC.

10.1.2 In order to assure that uniform results are being obtained in the test, calibration of storage box shall be completed by testing reference oil samples supplied by the TMC at the time calibration or recalibration is required. Reference oil performance and test operations are currently monitored by the TMC. Statistics for reference tests are published periodically by the TMC and provide acceptance ranges for the various oils. Method users shall contact the TMC for the most current values to evaluate referencing status.

10.1.2.1 *New Storage Box Calibration*- For a new storage box, reference tests as prescribed by the TMC shall be completed giving results within the established limits for the reference oils. Inspection of the new storage box for compliance with this standard method by the TMC is also required.

10.1.2.2 *In-Service Stand Calibration*- For a previously referenced storage box, reference tests giving results within the established limits for those oils shall be conducted at the frequency specified by the TMC. Test oils for this purpose are distributed as blind coded samples by the TMC when a request for calibration is received. All test starts and test data using reference oils shall be reported to the TMC.

10.1.2.2.1 *Reference Test Frequency* - One reference test is required every ten test starts or every three months, whichever comes first. This calibration frequency is subject to change as required. Current calibration information is available from the TMC.

10.1.3 All tests are consecutively numbered on a storage box basis. Each storage box has its own unique, permanent identifier. Every test start shall receive a sequential test run number designated before testing begins. All test starts, including aborted starts and operationally invalid tests, shall retain their test run number.

10.2 *Instrumentation Calibration*

10.2.1 *Drive Speed*—Calibration of the drive speed measuring system shall be done immediately prior to each stand calibration sequence against a known standard, traceable to NIST[11].

10.2.2 *Temperature*—Calibration of the temperature controller systems (storage box and motoring) shall be done immediately prior to each stand calibration sequence, traceable to NIST[11].

10.2.3 *Pressure Relief System*—Calibration of the pressure relief system shall be done immediately prior to each stand calibration sequence using the following process:

10.2.3.1 From the bottom of the dip tube, measure 27.75 ± 0.125 inches and mark this distance on the dip tube.

10.2.3.2 Apply 1 psi to the dip tube.

10.2.3.3 Fill the water column reservoir with specified test water (Section 7.1) until 1.0 psi is displaced.

10.2.3.4 Release the pressure in the dip tube, and mark the static water level on the dip tube.

10.2.3.5 Apply air pressure to the dip tube until air begins to bubble from the tube to verify calibration. Air pressure shall be 1 ± 0.1 psi.

11. TEST PROCEDURE

11.1 *Pre-Test, Start and Motoring Phase*

11.1.1 *Installation of Test Unit*-Install the assembled test unit on the motoring rig. Connect the driveshaft and temperature probe. Install the cooling fan and heat lamp pair as shown in Fig 3.

11.1.2 Adjust the temperature controller to maintain 180±1°F (83±0.6°C).

11.1.3 Record time and the initial oil temperature and immediately start the driving motor.

11.1.4 The time between the beginning of the abrasive blasting of axle parts to the start of the motoring phase of the test shall not exceed 8 hours.

CAUTION—Rotating test stand equipment presents a physical hazard and safety guards shall be used.

11.1.5 Add 1.00+/- .02 fl oz (29.6±0.6 ml) of specified test water with a syringe to the test unit through the full port valve within 5 minutes after starting the drive motor (Section 11.1.3). Connect the pressure relief system.

11.1.6 Monitor oil temperature and when the oil temperature reaches 180±1°F (83±0.6°C), close full port ball valve, disconnect the pressure relief system, and plug the downstream side of valve. This prevents escape of any additional water vapor. Measure and record drive pinion r/min and oil temperature, and report the time at the beginning of motoring phase. The maximum allowable warm-up time for the oil to reach operating temperature of 180±1°F (83±0.6°C) is 1 hour.

Note 3: On rare occasions, a small amount of the test oil/water emulsion will foam up from the carrier into the accumulator during heat-up. There are occasions when the material will not completely drain back into the carrier as the unit reaches operating temperature. Labs shall report the estimated amount that did not return to the carrier in the comment section of the test report.

11.1.7 Motor the test unit for 4.0 ± 0.1 hours at 180±1°F (83±0.6°C) and 2,500 +/- 25 r/min.

11.1.8 At the end of the motoring phase, measure and record drive pinion r/min and report the time. Stop the driving motor, turn off the heat lamps and cooling fan.

11.2 *Transition Phase*

11.2.1 The test unit shall be moved to the storage box within 30 minutes of the end of the motoring phase. See Fig. 6 for physical position. The controller is set at $125\pm1^{O}F(52\pm0.6^{O}C)$. Position the axle such that the axle tube openings and the pinion shaft are on a horizontal plane

11.2.2 Switch on the internal fan. Activate the control system to maintain a test oil temperature of $125\pm1^{O}F(52\pm0.6^{O}C)$. The maximum allowable time for the test oil to reach operating temperature of $125\pm1^{O}F(52\pm0.6^{O}C)$ from the end of the motoring phase of the test (Section 11.1.8) is 1.5 hours.

11.3 *Storage Phase*

11.3.1 Record the time of the first occurrence of the test oil temperature reaching 125±1°F (52±0.6°C). This is the start of the storage phase.

11.3.2 Continue the storage phase for a total of 162 +/- 0.2 h.

11.3.3 At the end of the storage phase, record the time, then switch off the storage box heating unit and circulating fan. The end of the storage phase is the end of the test.

11.4 *Post Test Procedure*

11.4.1 Immediately remove the test unit from the storage box. Disconnect the temperature sensor. Drain and discard the used test oil. Completely disassemble the test axle within 1 hour after the test completes (Section 11.3.3).

11.4.2 Lightly pressure wash all parts with a hydrocarbon solvent to remove used test oil.

11.4.3 Immediately coat test parts in Mobil Arma 245 prior to final rating.

11.4.4 All parts shall be cleaned and coated in Mobil Arma 245 within 1 hour after disassembling the test axle.

11.4.5 If the rating is not to be conducted within 24 hours of end of test, the coated test parts shall either be stored submerged in the preservative oil, or stored as-is in airtight, closed containers. Wrapping the test parts in NOX-RUST paper[4] for long term storage has also been found to be acceptable**.**

Note 4: To preserve test parts in storage or for shipment after completion of all rating and optional documentation photographs, the rust preventative Mobil Arma 245 has been found to be effective in preventing new rust buildup in post-test ambient storage conditions.

12. DETERMINATION OF TEST RESULTS

12.1 Rating shall be conducted within 14 days from the end of test, under lighting conditions described in CRC Manual 21. Parts shall be rated in accordance to CRC Manual 21 and Annex A4. The rating procedure described in Annex A4 supersede those found in CRC Rating Manual 21 where applicable. Deposits on rated items will fall under one of two categories: (1) Rust or corrosion; (2) Stain and sludge or other.

12.2 Rust or corrosion deposits will be assigned one of the following integer values: 10, 9, 8, 5, or 0, using these definitions:

None	= 10		
Trace	= 9	=	not more than six spots, each less than 1 mm in diameter.
Light	= 8	=	seven(7) or more spots less than 1 mm in diameter or, one(1) or more spots greater or equal to 1 mm in diameter with a combined area of all the spots no greater than 1% of the total rated component surface.
Moderate	= 5	=	in excess of above and up to 5% of considered surface
Severe	= 0	=	covering more than 5% of considered surface

12.3 The following areas will be rated as described above:

Area Number	Description
1	Differential case pinion contact thrust surfaces
2	Differential case side gear thrust surface and Hub I.D.
3	Differential gears (side gears) thrust surface and Hub O.D.
4	Axle housing cover plate without the plug
5	Ring gear (Drive gear) tooth surfaces
6	Drive pinion tooth surfaces
7	Drive pinion roller surfaces
8	Drive pinion cup (total raceway length)
9	Differential case roller surfaces
10	Differential case cup (total raceway length)

12.4 By filling in values on the rating sheet then applying the appropriate weighting values shown, a final deposit merit value will be obtained. Note the presence, location and amount of additional deposits, i.e., stain and sludge or other, in the“ Remarks” section on the rating sheet. Also note rust in non-rated areas in the “Remarks” section.

12.5 For a valid rating, the test shall be rated by an individual who has participated in an ASTM sponsored, high volume gear rater calibration workshop within the previous 12 months.

12.6 Test Validity: The test is determined to be operationally valid if the critical operating parameters and number of downtimes are within the limits specified and defined in Annex A 2.

13. FINAL TEST REPORT

Report all items using the current report format which is available from the Test Monitoring Center. Annex A3 lists the required forms for reporting the test data.

14. PRECISION AND BIAS

14.1 *Precision:*

Test precision is established on the basis of reference oil test results (for operationally valid tests) monitored by the ASTM Test Monitoring Center.

Table 1 summarizes reference oil precision and reproducibility of the test as of April 30, 1997.

Table 1 **Test Precision—Reference Oils 121, 122, 123, and 125**

			Final Merit Rating		
Oil Code	N	Normal Dist.	X	r	R
TMC 121	12	Yes	9.37	0.81	0.81
TMC 123	65	Yes	9.02	0.84	0.97

14.1.1 Repeatability (r) is defined as: the difference between successive results obtained by the same lab under constant operating conditions on the same oil, would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 1 in only one case in twenty.

14.1.2 Reproducibility (R) is defined as: the difference between two single and independent results obtained by different operators working in different laboratories on the same oil would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 1 in only one case in twenty.

14.2 *Bias:*

14.2.1 No estimate of bias is possible, as the behavior of a lubricant is determined only under specific conditions of the test and no absolute standards exist.

15. KEYWORDS

15.1 Corrosion, final drive axle, gear failure, gears, lubricants, L-33, moisture, rust.

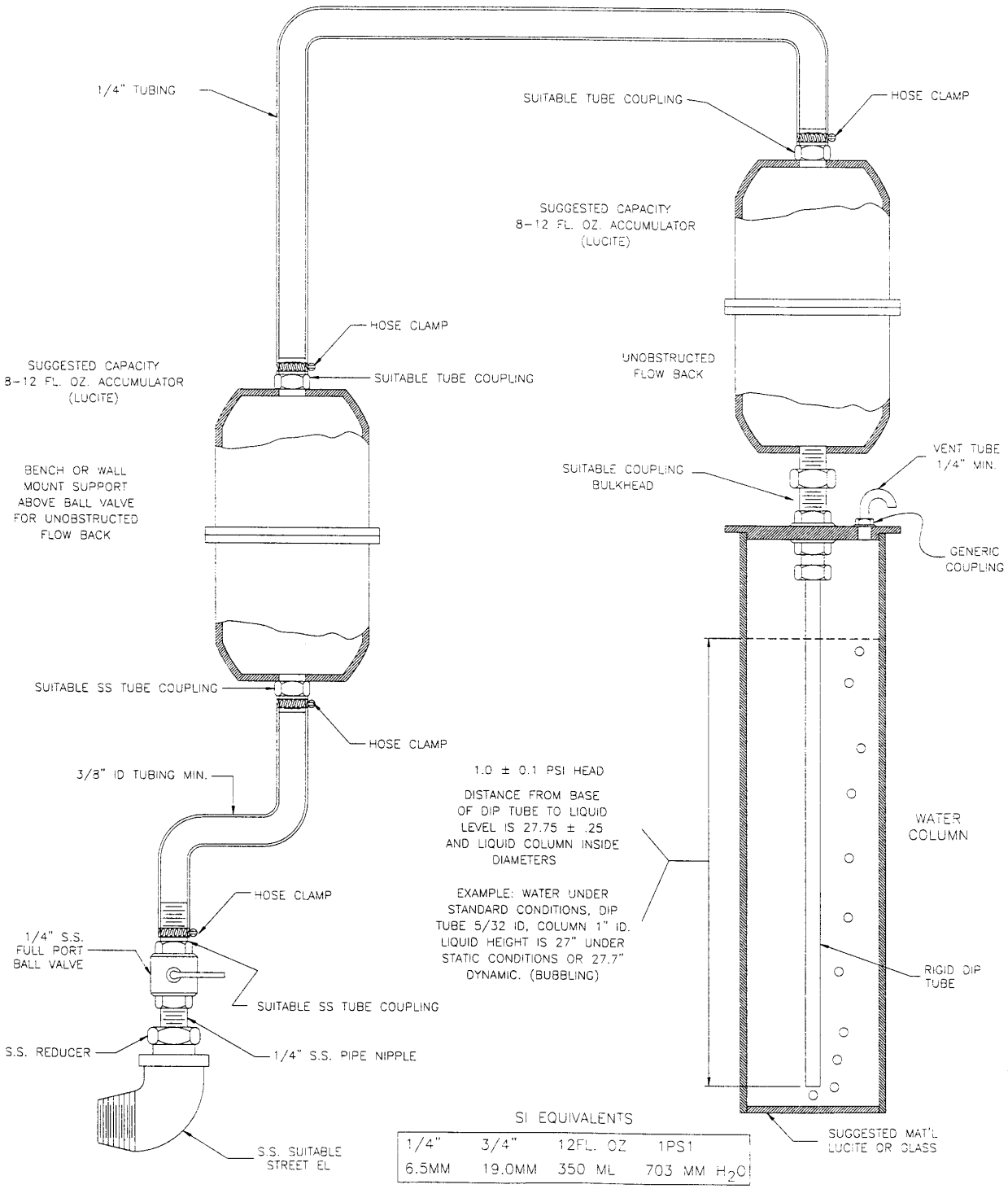
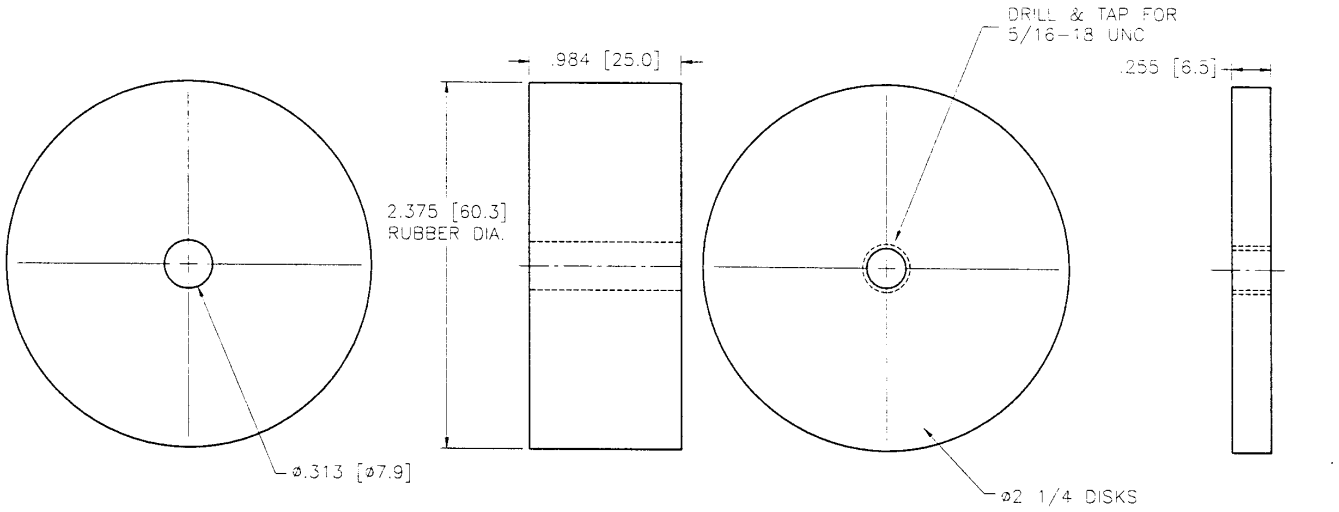
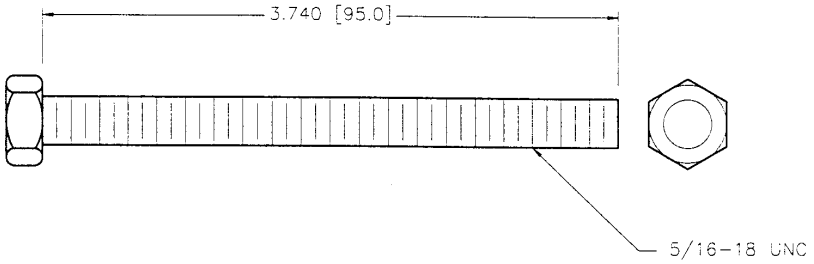


Figure 1 Pressure Control System

Suggested
Axle Seals



SUGGESTED SEAL MATERIAL – NEOPRENE



BOLT AND WASHERS – STAINLESS STEEL\

DIMENSIONS ARE IN INCHES[MILLIMETERS]

Figure 2 Axle Seals

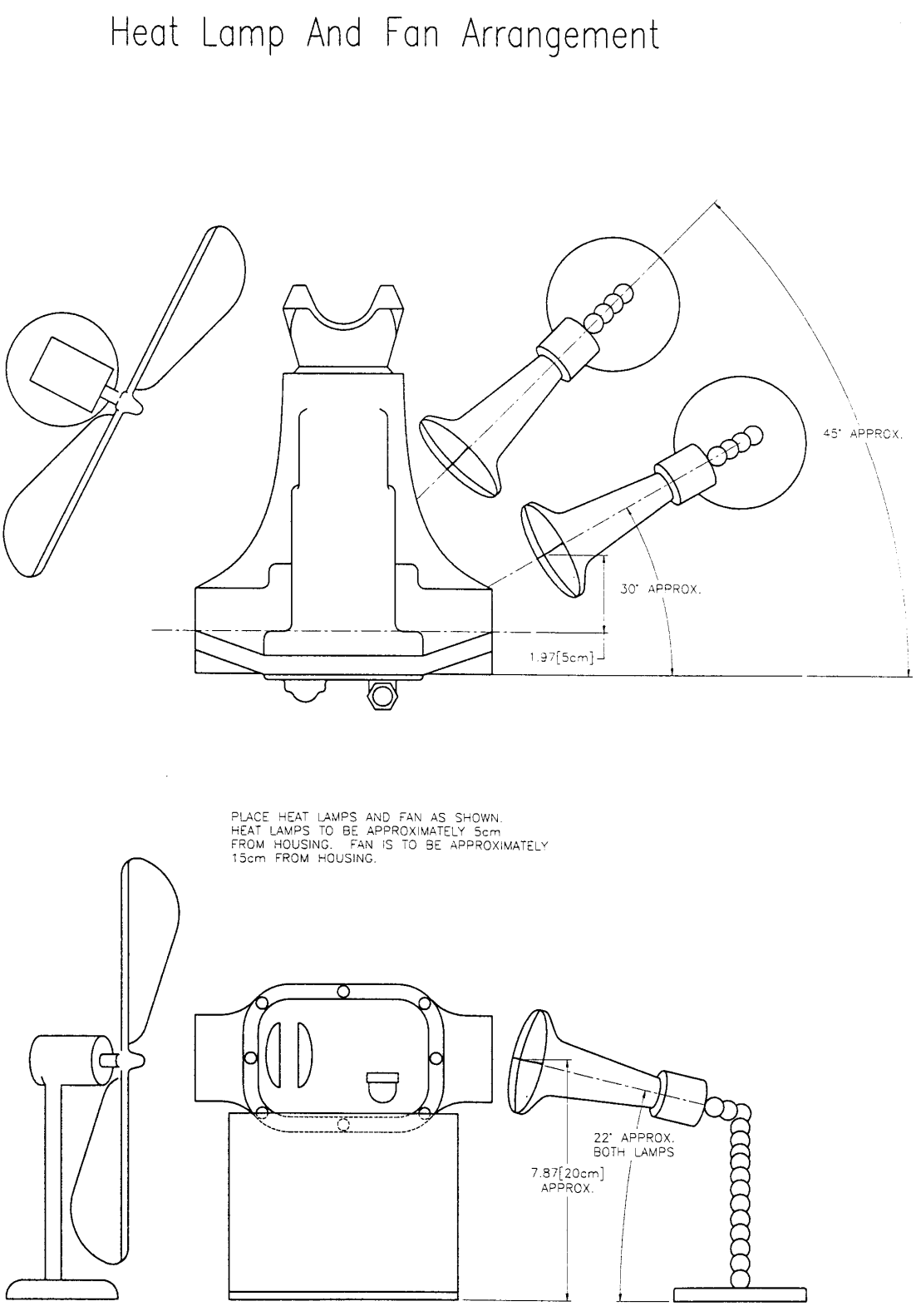


Figure 3 Heat lamp And Fan Arrangement

Temperature Probe Location

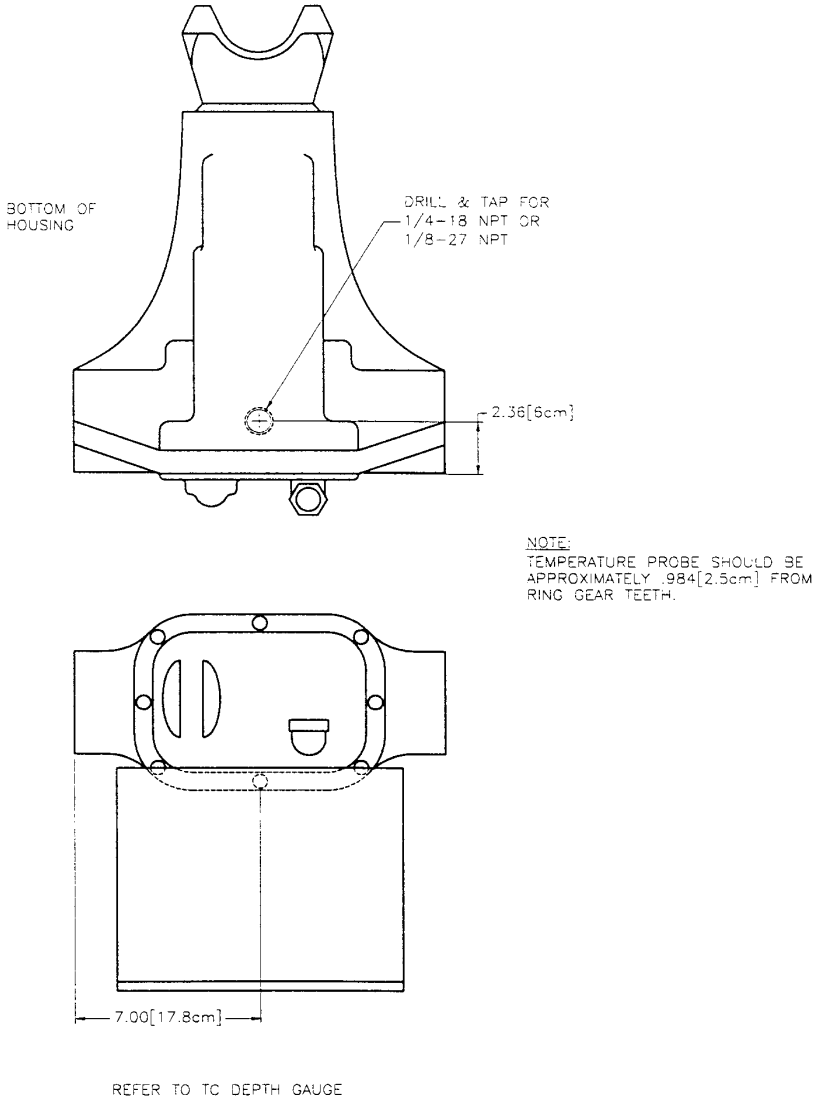


Figure 4 Temperature Probe Location

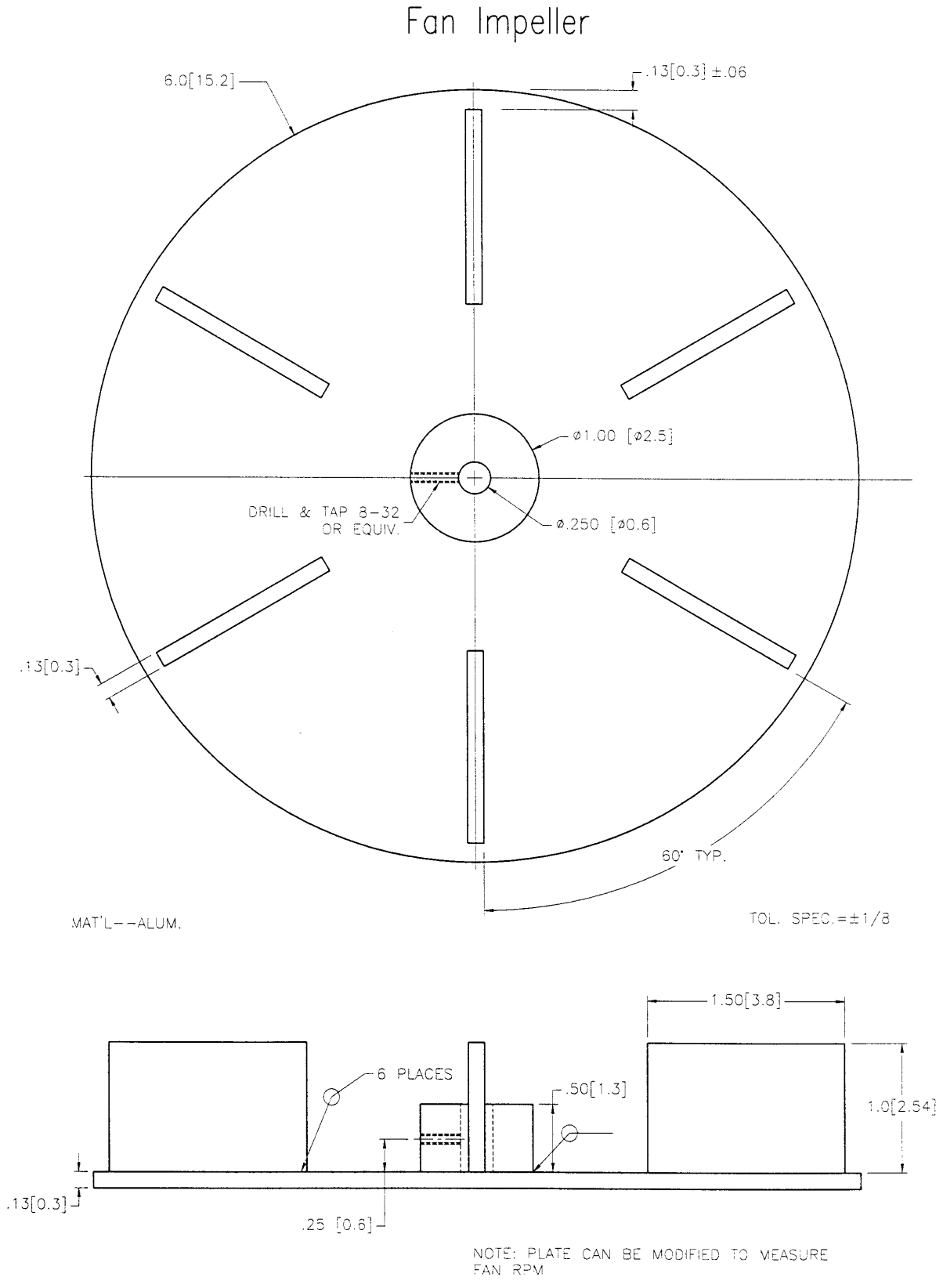
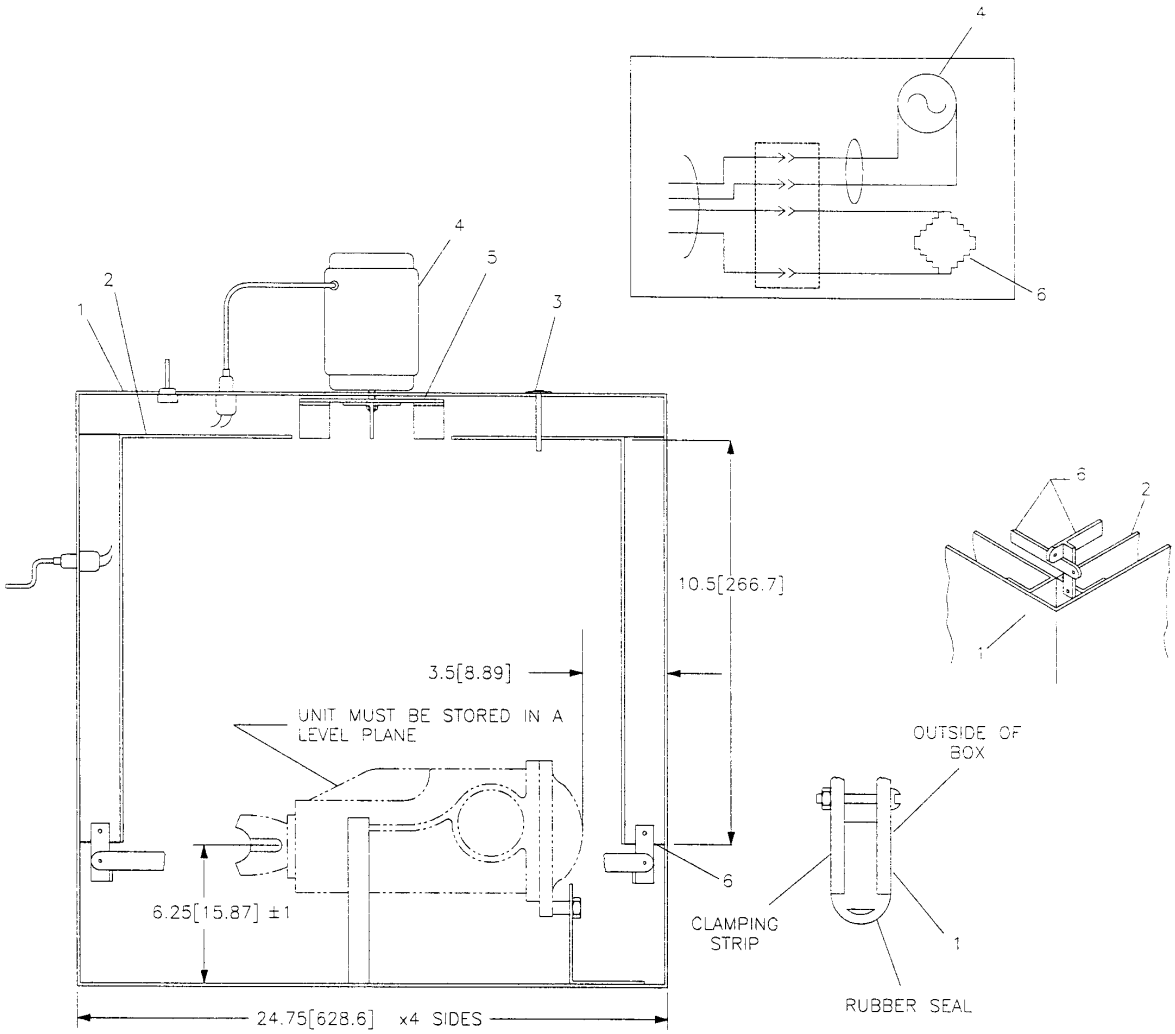


Figure 5 Fan Impeller

Controlled Temperature Storage Box



1. OUTER BOX 24.75 x 24.75 x 18 ±1[61.9 x 61.9 x 45.7] ALUMINUM, WELDED SEAMS.
2. INNER BAFFLE 21 x 21 x 10.5 ±1[53.3 x 53.3 x 26.6] ALUMINUM, WELDED SEAMS
3. APPROPRIATE CONNECTORS SHOULD BE USED FOR INSTALLATION
4. FAN MOTOR, (DAYTON 3M562, OR EQUIV. 1550 RPM, 115 VOLT ELECTRIC MOTOR)
5. FAN IMPELLER--REFER TO IMPELLER FIGURE
6. HEATING ELEMENT, 110 VOLT, 500 WATT TOTAL BOX STRIP HEATERS NO. S2450, OR EQUIV.

NOTE:
DIMENSIONS ARE IN INCHES[CENTIMETERS]

Figure 6 Controlled Temperature Storage Box

Rated Surfaces
Differential Case

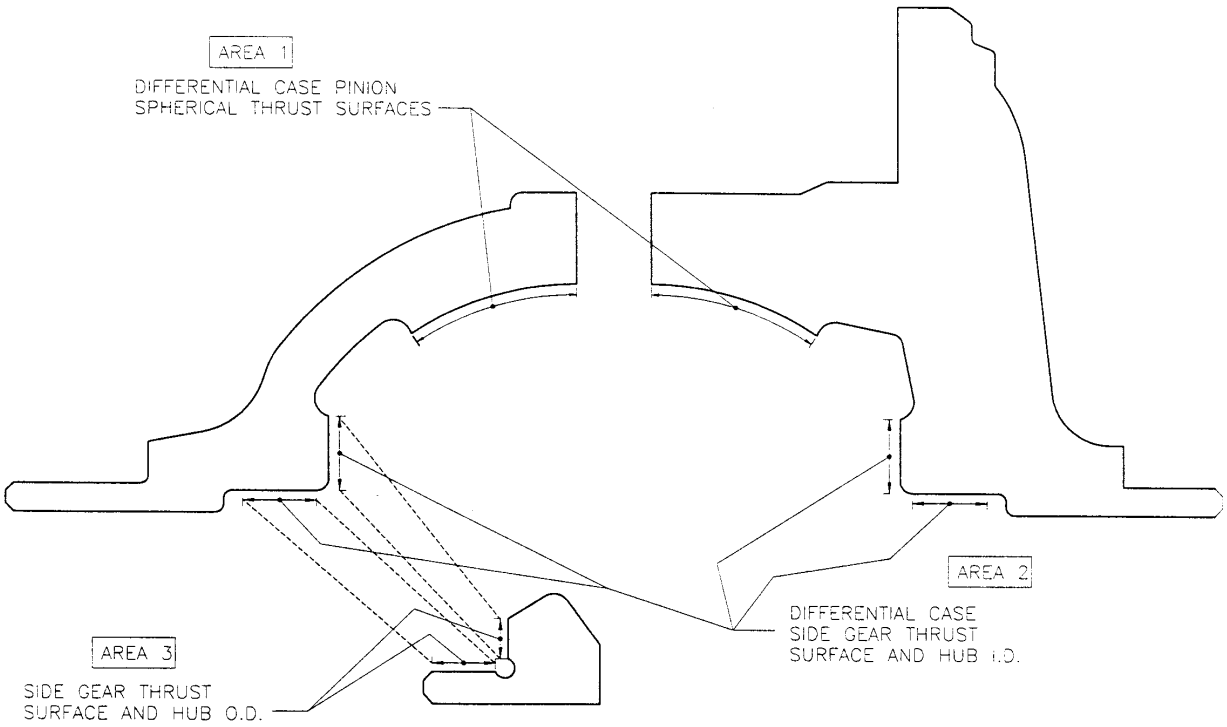


Figure 7 Differential Case

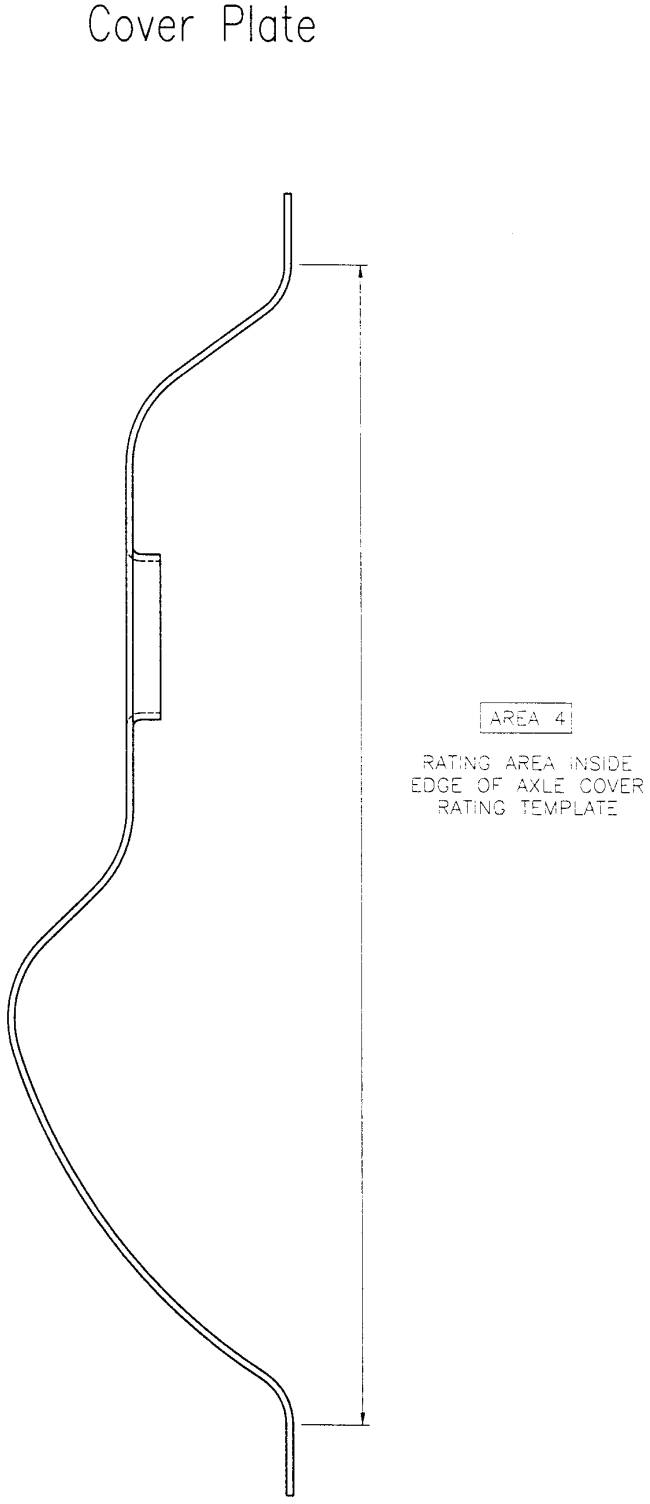


Figure 8 Cover Plate

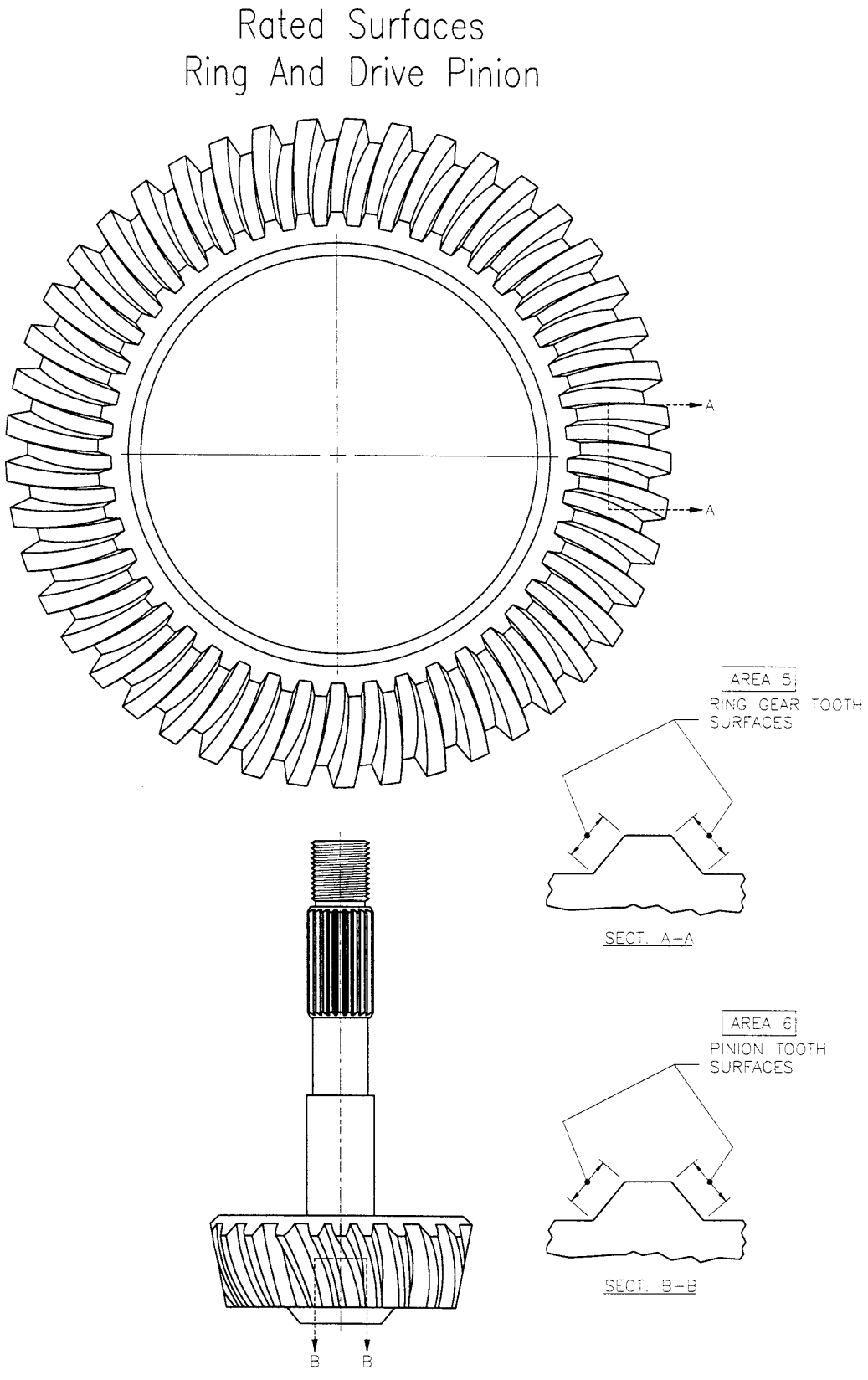


Figure 9 Ring and Drive Pinion

Rated Surfaces
Drive Pinion Roller Bearings

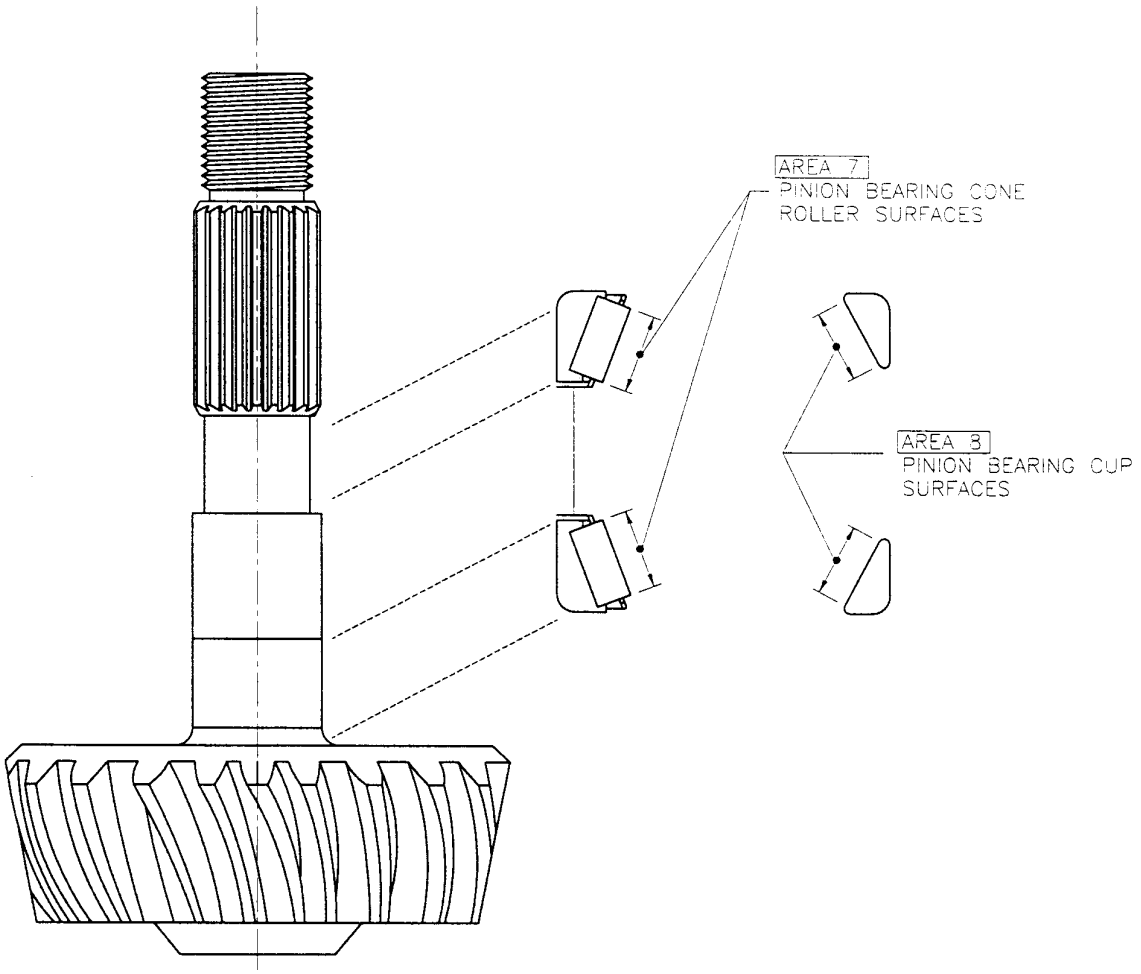


Figure 10 Drive Pinion Roller Bearings

Rated Surfaces
Differential Case Roller Bearings

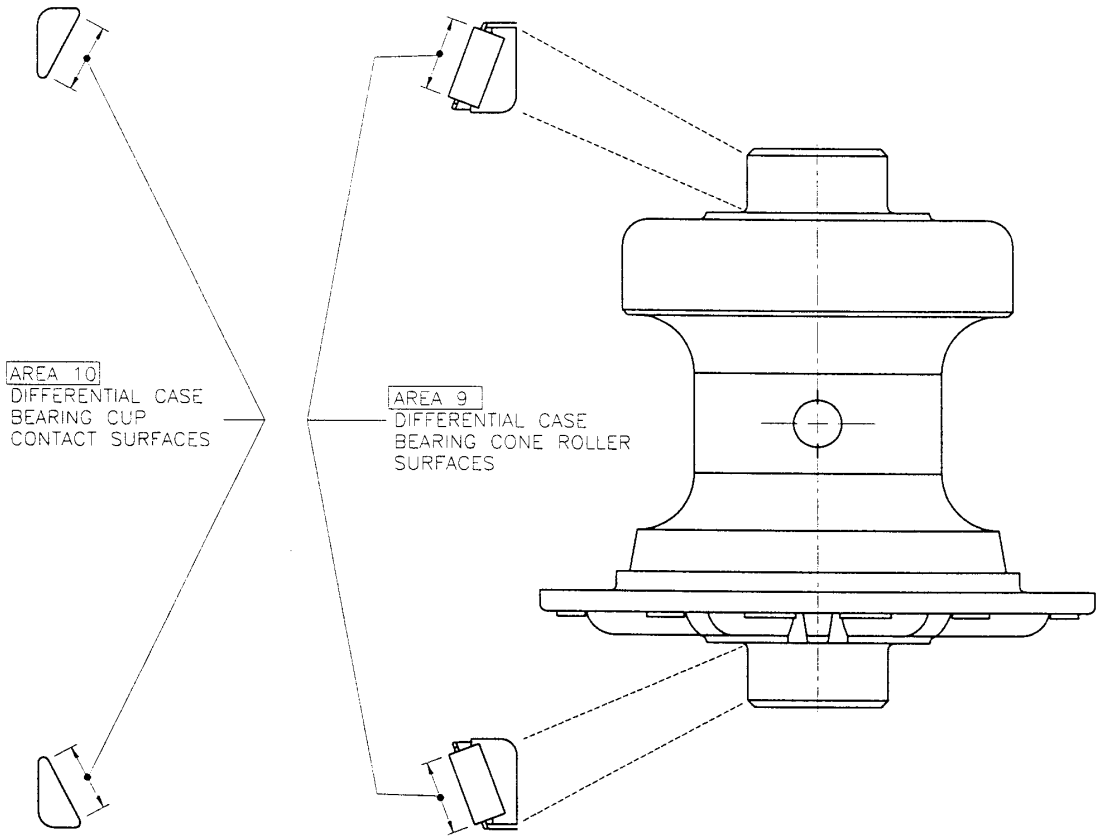
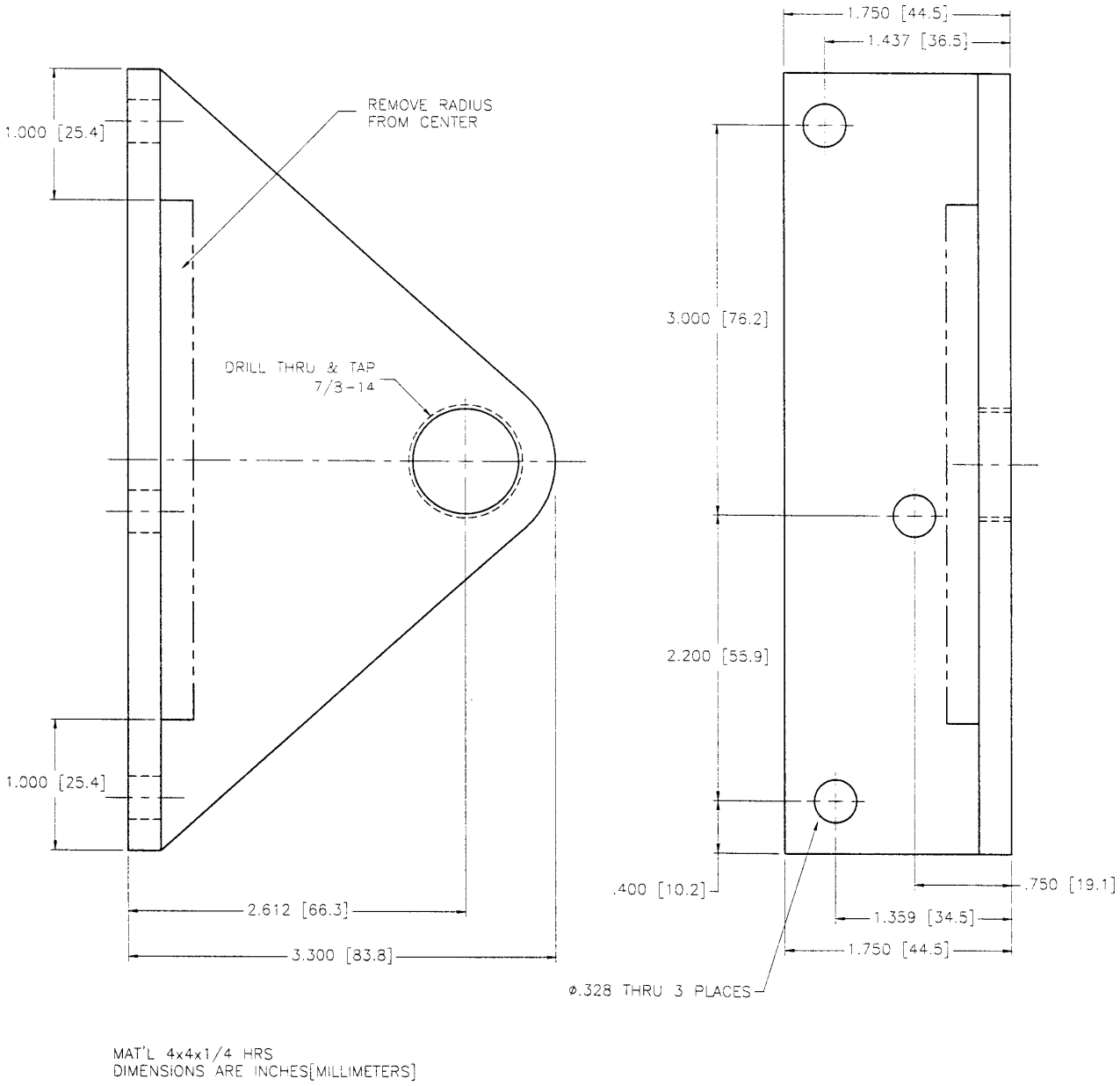


Figure 11 Differential Case Roller Bearings

Drill And Tap Fixture



MAT'L 4x4x1/4 HRS
DIMENSIONS ARE INCHES[MILLIMETERS]

Figure 12 Drill and Tap Fixture

Drill And Tap Bushings

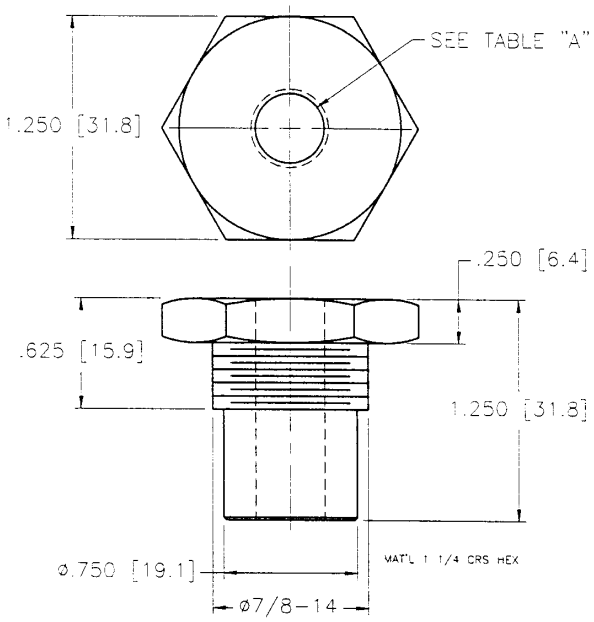
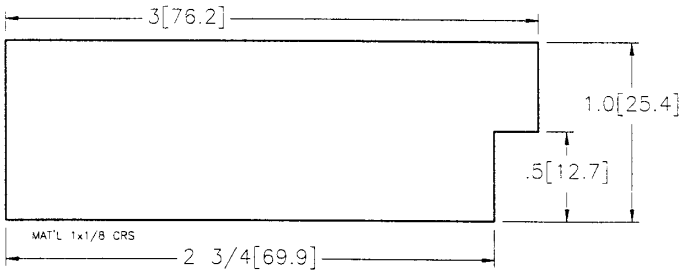


TABLE A

FOR BUSHING ID	GUIDE FOR
.328	1/8-27 NPT DRILLING
.438	1/8-27 NPT TAPPING
.438	1/4-18 NPT DRILLING
.578	1/4-18 NPT TAPPING



THERMOCOUPLE DEPTH GAUGE

DIMENSIONS ARE INCHES[MILLIMETERS]

Figure 13 Drill and Tap Bushings

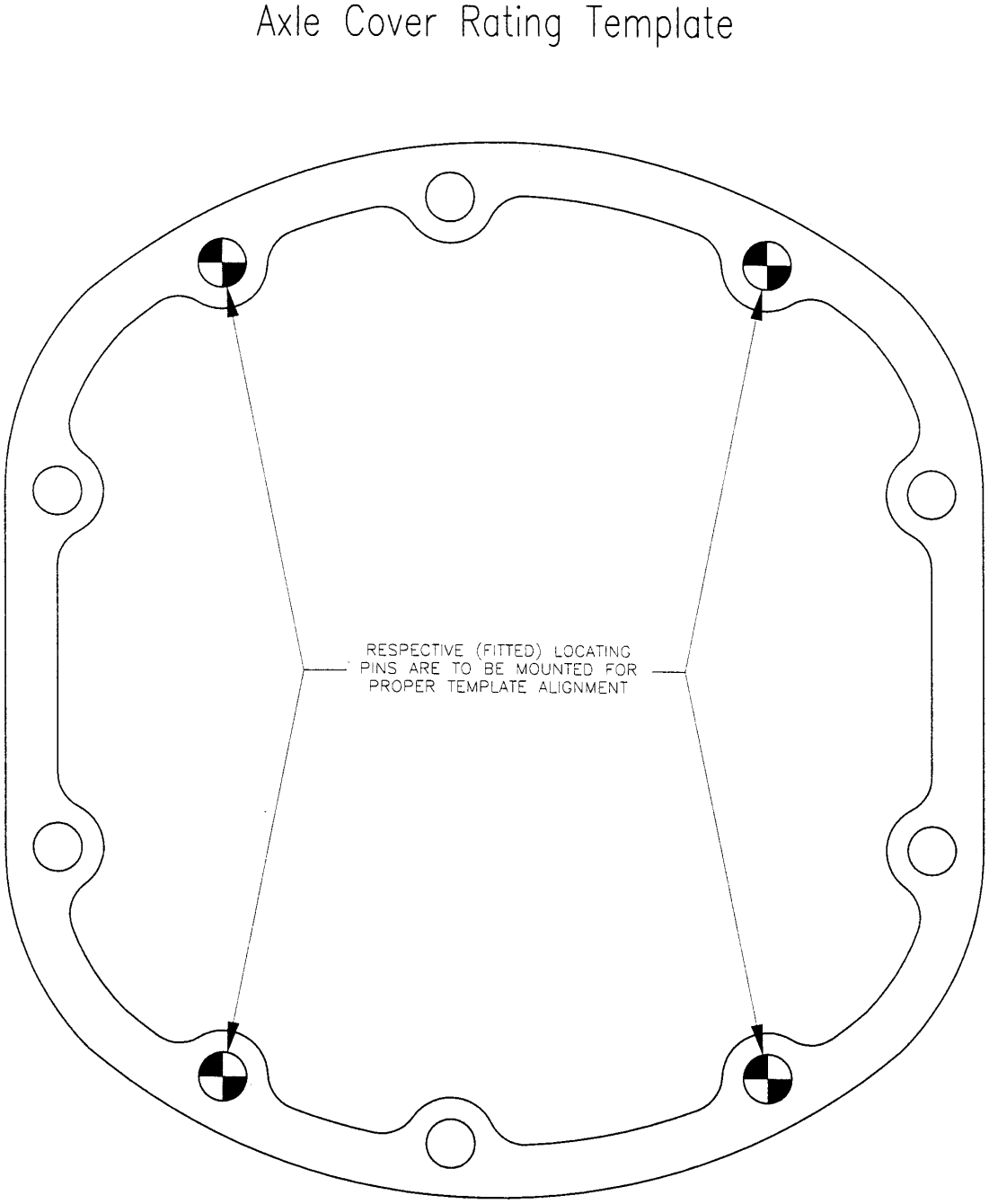


Figure 14 Axle Cover Rating Template

Annex A-1

PRECAUTIONARY STATEMENTS

A 1.1 *Hydrocarbon Solvent*

DANGER- Combustible. Vapor harmful
Keep away from heat, sparks and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A 1.2 *Mobil Arma 245*

DANGER - Combustible material.
Harmful or fatal if swallowed.
Keep away from heat, sparks and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.
If swallowed, do not induce vomiting. Call physician immediately.

Annex A-2

Test Validity Calculation and Limits

A 2.1 For a test to be operationally valid it shall not exceed the limits on unscheduled down-time and deviation from critical operating parameters.

A 2.2 *Downtime Limits*

A 2.2.1 Motor Phase: Warm-up-No limit on number of occurrences.

A 2.2.2 Motor Phase: A maximum number of 2 downtime occurrences are permitted with a total downtime not to exceed 15 minutes.

A 2.2.3 Storage Phase: A maximum number of three occurrences for a total downtime not to exceed 30 minutes.

A3. L-33 TEST REPORT FORMS and DATA DICTIONARY

The required report forms and data dictionary are available on the ASTM Test Monitoring Center Web Page at http://tmc.astm.cmri.cmu.edu/ or can be obtained in hardcopy format from the TMC.

Form 0	Test Report Cover
Form 1	Test Result Summary Page
Form 2	Rating and Test Operational Summary
Form 3	Lost Time and Comments Sheet
Form 4	Pre Test Rating

A4. L-33 Rating Procedure

A4.1 Additional information has been added to aid the rater in accurately assessing the rust and corrosion following the completion of the test. The steps in this annex supercede those found in CRC Rating Manual 21 where applicable.

A4.2 Parts are to be coated with Mobil Arma 245 prior to rating.

A4.3 Examine the part before wiping. Note any suspicious observations. Mobil Arma tends to enhance the appearance of rust. It is advantageous to find questionable areas prior to wiping the cover

A4.4 Wipe the part with a soft lint free material to remove any excess Mobil Arma, sludge or stain residue. Only one wipe is permitted.

A4.5 Rate each area without magnification. Magnification is not to be used for determining additional rust or subdivision of a predetermined spot of rust.

A4.6 If a spot of rust is encountered that is beyond reasonable confirmation without magnification, use 10X magnification only on that spot to determine if it is rust. If after using 10X magnification on the suspicious spot and it is still inconclusive, the evaluation should be that the condition is not rust.

A4.7 Note in rater comments if magnification was used and what area.

A4.8 Rate the V99.1 hardware with the cover plate template (Fig. 14).

FOOTNOTES

[1] Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

[2] Available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-5094

[3] Available from the Coordinating Research Council, 219 Perimeter Center Parkway NE, Atlanta, GA 30346

[4] Available from the Defense Printing Service Office, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094

[5] Spicer Axle Division, Dana Corporation, P.O. Box 1209, Fort Wayne, Indiana 46801

[6] Available from a Power Drive Parts Distributor

[7] Arco Packing Company, PO Box 66, 515 Cedar Way, Oakmont, PA 15139, 412-828-6606
Request ASTM L-33 Die

[8] ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15206-4489

[9] Treiber Schleifmittel North American, Inc. 2000 College Avenue, M.P.O. Box 1438, Niagra Falls, NY 14302, USA

[10] Mobil Oil Company, Fairfax, VA

[11] National Institute of Standards and Technology (formerly National Bureau of Standards), Gaithersburg, MD 20899