



Turbo Waste Gate Linkage Wear Test Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This is a material test procedure to evaluate wear of materials during oscillating sliding using a pin-on-plate apparatus. Effects taken into consideration are loading, frequency, stroke, temperature and environment. Materials are tested in pairs under nominally non-abrasive, unlubricated conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction, wear volume and wear depth may also be determined.

1.2 Applicability. This test procedure was developed to help evaluate wear on turbo charger waste gate linkage components but could potentially be applied to other components if test conditions are modified to reflect the particular conditions of that component. This test allows for relative comparisons between different linkage systems including materials and material conditions to evaluate wear mechanisms and their rate of progression, including the effects of temperature, corrosive environments and generated third body particles. This validation procedure is not intended to replace engine or vehicle durability testing. Instead, it is intended to evaluate the linkage subsystem in a controlled and repeatable environment in advance of engine and vehicle availability. Therefore, the objective is to bench test candidate linkage materials in a fixture in a laboratory environment.

1.3 Remarks. This specification is based off of ASTM G99, which was modified specifically for the turbo charger. There are various wear mechanisms. Some of the more common ways that wear can occur in the linkage interfaces are listed in Table 1. This accelerated test procedure is intended to expose the candidate linkage materials to these types of wear mechanisms to the extent that the linkage is expected to be exposed to them in the vehicle application. A rigorous process of cyclic loading under typical and high temperature conditions combined with corrosive environment exposure is utilized to provide an accelerated test approach.

Table 1: Common Wear Mechanisms Found in the Waste Gate

Types of Wear	Definition	Conditions Promoting Wear
Severe Adhesion (cold welding)	Cold welding of metal surfaces due to intimate metal to metal contact. $V/L = KP/H$	High loads, speeds and/or temperature Use of stainless steels or aluminum Lack of anti-scuff additives
Abrasion	Cutting and deformation of materials by hard particles (3 body) or hard protuberances (2 body). $V/L = KP/H$	Insufficient metal hardness Hard metal with rough surface against soft metal
Contact Fatigue	Metal removed by cracking and pitting due to cyclic elastic stress during rolling and sliding.	Cyclic stress over long periods Inclusions in steel Particles of metal with sharp edges Metal spheres by microscopy
Corrosion	Rubbing of corrosion products on a surface.	Corrosive environment Corroding metals Rust promoting conditions High temperature
Fretting	Wear between two solid surfaces experiencing oscillatory motion of low amplitude.	Vibration causing relative motion

1.4 Summary of Test Procedure. Two specimens are required; one, a pin with a radiused tip, is position perpendicular to the other, a flat plate. The test machine causes the pin specimen to slide in an oscillating fashion across the plate. The pin specimen is pressed against the plate at a specified load by an arm or lever via spring, hydraulic or pneumatic means. A heating method is applied.

1.5 Measuring Wear. Wear results are reported as both wear depth in millimeters and volume loss in cubic millimeters for the pin and plate separately. The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after test. This can be determined by any suitable metrological technique, such as electronic distance gaging or stylus profiling. Mass loss is often too small to measure precisely. Note that wear volume plots may display non-linear relationships between wear volume and distance over certain portions of the total sliding distance and linear relationships over other portions. Causes for such differing relationships include initial break in processes, transitions between regions of different dominant wear mechanisms, wearing through heat treated areas, and so forth. The extent of such non-linear periods depends on the details of the test system, materials, and test conditions. It is not recommended that continuous wear depth data obtained from position-sensing gages be used because of the complicated effects of wear debris and transfer films present in the contact gap, and interferences from thermal expansion or contraction.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM E384

ASTM G99

ISO 9227

ISO 17025

2.2 GM Standards/Specifications.

None

3 Resources

3.1 Facilities. Testing shall be conducted at a facility that is certified in and familiar with pin on plate wear testing.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

If other test parameters are varied such as load, speed, environment, etc. with agreement between GM Product Engineering and Supplier, it must be clearly stated and reported which test parameters were different.

3.2 Equipment. All equipment listed in ISO 9227 plus that which is listed in 3.2.

3.2.1 Wear Cycle Test Unit Actuation Mechanism.

- The wear cycle test unit shall have a mechanism such as an electric motor that is capable of exerting forces equivalent or higher than are applied by the WG actuator.
- The mechanism shall move the linkage to full travel on each cycle.
- The mechanism may be capable of varying cycle time, but shall be capable of 80 Hz.
- The mechanism may be protected from the linkage environmental conditions, such as heat.

3.2.2 Wear Cycle Test Unit Reaction Mechanism.

- The wear cycle test unit shall have a mechanism such as a spring, pneumatic or hydraulic loaded arm that is capable of applying the necessary reaction load, up to a 100 N load.
- This mechanism shall not apply unusual constraints or moments that do not represent forces or conditions that the candidate mechanism wouldn't see in operation.
- This mechanism shall apply reaction forces on the candidate mechanism in the same direction and manner to enable equivalent linkage deflections and moments that would be typical in the intended application.
- The mechanism shall be structurally capable to produce the motion at the test sample interface location to that of the transducer location indicated motion.

3.2.3 Wear Cycle Test Unit Support Fixture.

- The plate may be connected directly to the actuation mechanism. The pin must be connected to an arm that will exhibit the same deflection and torque characteristics as the intended application.

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3.2.4 Wear Cycle Test Unit Environmental Requirements.

- The wear cycle test unit shall be configured with a heating mechanism capable of controlling the test linkage mechanism to the appropriate temperature. This can be done by induction heating or by some other heating device.
- There is no requirement on this test fixture for salt spray or other humidity controls. However, the test shall be conducted in a controlled environment such as a test cell.

3.2.5 Wear Profilometer requirements:

- Capable of 3D non-destructive measurements of the sample surface, both Ra and Sa.
- Ability to analyze on the wear scar for the wear depth and wear volume.
- Z (height) resolution of 20 nm and x-y (lateral) resolution < 3.5 μm .
- Z (height) accuracy of $\pm 0.05\%$ for 50 μm step.
- Sufficient scanning area to cover the worn area. For the current test design, a 4 mm x 10 mm image size is required on the pin side, and 6 mm x 8 mm image size is required on the plate side.
- Sufficient scanning distance to capture the major shape of the sample and wear mark depth around the worn area. For current test design, 1mm scanning distance is required.

3.3 Test Vehicle/Test Piece. This test method may be applied to a variety of materials. Specimens must withstand the stresses imposed during the test without failure or excessive flexure. The materials being tested shall be described by dimensions, surface finish, material type, processing condition, heat treatment and/or plating depth/thickness, hardness, composition, microstructure, and microhardness. The test piece shall reflect the production intent linkage assembly including material, material conditioning including heat treatment, surface finish, geometry and any other critical characteristic that could affect the linkage functionality. Any coatings or surface treatments to enhance corrosion or wear resistance shall be applied and within specifications.

3.3.1 Surface Finish. A ground surface roughness of $R_a = 3.2$ or less is required for the pin and plate. Care must be taken in surface preparation to avoid subsurface damage that alters the material significantly. Special surface preparation may be appropriate for some test programs, which is to be discussed with the Technical Specialist ahead of time.

3.3.2 Specimen Geometry. The pin and plate dimensions are shown in Figure 1 and Figure 2. The pin dimensions at the oscillation-friction wear machine attachment point may differ. Likewise the plate width and length may need to change to fit the oscillation-friction wear machine's holder capacity.

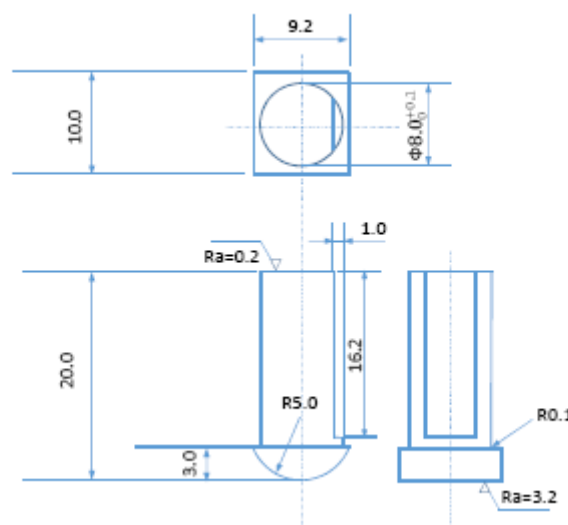


Figure 1: Pin Dimensions

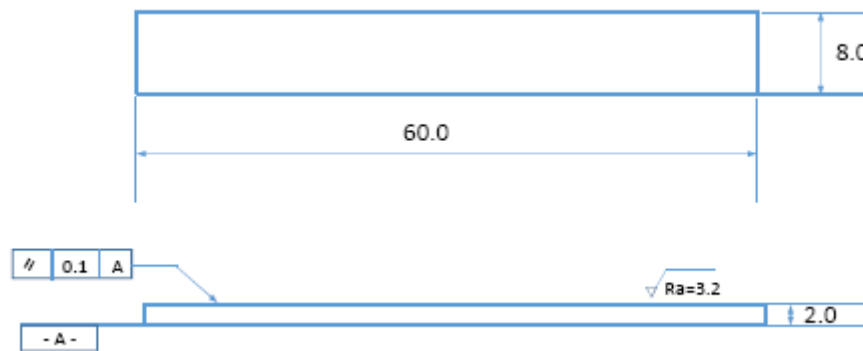


Figure 2: Plate Dimensions

3.3.3 Turbo Component Specimen Geometry. The supplier and Global Propulsion Systems Technical Specialist and Tribologist shall come to agreement on what specimen geometry is appropriate for each turbo component pair being tested if there are deviations from Table 2.

Table 2: Turbo Component Specimen Geometry

Turbo Component	Specimen Geometry
Actuator Rods	Plate
Pins	Pin
Spring Cups	Pin
Bushings	Plate
Shafts	Pin

3.4 Test Time.

Calendar time: 6 weeks

3.5 Test Required Information. See Data Sheet A1 in Appendix A for a list of test information.

3.6 Personnel/Skills. Per ISO 17025 Section 5.2.

4 Procedure

4.1 Preparation. Parts shall be supplied using production intent equipment and processes whenever possible. Any practices that deviate from production shall be agreed to ahead of time and noted on the test report. Coatings/platings and surface treatments shall target conditions considered to be typical in production unless otherwise stated.

4.1.1. Initial State. Retain specimens that were made from the same batch of the specimens being wear tested. These specimens shall be evaluated to record the initial conditions. On each set of specimens, record:

- Material type/grade,
- Micro hardness per ASTM E384,
- Coating/plating type and conforming specification,
- Coating/plating thickness and hardness and note the measurement methodology,
- Surface treatment type, hardness and thickness,
- Other significant characteristics of the part that can influence wear properties.

4.2 Conditions. Parts will alternate wear cycling with corrosion cycling per the schedule in Table 3, unless otherwise noted. The wear test shall run for a total of 100 000 cycles of full range actuation for sliding abrasive

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