



Coolant Pump Mechanical Face Seal Durability

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.

Note: The words **must**, **shall** or **will** as used in this document mean a mandatory requirement.

1.1 Purpose. This test is designed to examine the life of coolant pump mechanical face seals when subjected to temperature cycling, varying inlet/outlet pressures and varying shaft speeds.

1.2 Applicability. This test is suited to the evaluation of all passenger car and light/medium duty truck mechanical face seals.

1.2.1 Design has a significant influence on test results. The largest GM designed pump currently in production on the Large Gas Engine (LGE) was used in the development of this diurnal test cycle. This test is to be used on components and coolant pump assemblies to identify and eliminate poor mechanical seal designs and/or materials. It can serve as a development, validation, or benchmark test. The water pump assembly, including gasket/seal, fasteners and structural interfaces is cycled on a thermal and rotational schedule while coolant is circulated internally.

1.2.2 Changes over time in the size of the largest mechanical seal water pump will require a change in 24 h Appendix B schedule. This will be reviewed no later than every five (5) year refresh of the document content.

1.3 Remarks.

1.3.1 Functional evaluation of external water pump assemblies to the engine gaskets (e.g., water pump cover or water pump to head or block) are subjected to GMW3155 leak test performance and are not part of this test evaluation.

1.3.2 This durability procedure, using two worst case pumps, evaluates the endurance requirements of coolant pump seals. The test sequence has a range of speeds, temperatures, pressures, and short periods of coolant drained from the pump to rapidly accumulate seal aging and to accelerate mechanical seal wear.

1.3.2.1 Criteria. Validation requires completion of the test schedules described herein without exceeding the cumulative limit of 100 ml of vapor and liquid leakage (as defined in Section 5: Performance Criteria).

1.3.2.2 Part Conditions Requiring Retest. Design changes requiring complete re-validation include, but are not limited to:

- Changes in the seal ring or mating ring material,
- The seal production process,
- The specification of the installed height, or
- The interference fit

1.3.2.3 End of Test Criteria. Following completion of the durability test, the measurements and inspection outlined in 5.3 shall be completed and the results documented in a report.

2 References

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

2.1 External Standards/Specifications.

ASTM E168	IATF 16949	ISO 4650
ASTM D1415	ISO 48	ISO/IEC 17025

2.2 GM Standards/Specifications.

GMW3155

GMW3420

2.3 Additional References.

- Mahr Federal, 1144 Eddy Street, Providence, R.I. 02905, www.mahr.com

3 Resources

3.1 Facilities. A suitable lab area or room, with a stable and known environment, is needed to conduct testing. See Test Conditions in 4.2.2. There must also be the capability to safely handle engine coolant.

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.

3.1.3 Lab Certification. All data must be generated by an ISO/IEC 17025, International Automotive Task Force (IATF) IATF 16949 or GM accredited laboratory. A schedule for machine maintenance and instrument calibration should be available for inspection.

3.2 Equipment. (See Table 1, Table 2 and Appendix C, Figure C1). Programmable rotational test equipment with a peak shaft speed of 10 000 revolutions per minute (rpm), with speed accuracy of ± 20 rpm is required. The water pump assembly must be mounted to a fixture that represents the coolant flow characteristics of the pump as it is installed in the engine. This can be accomplished by either using the actual engine hardware (e.g., front cover, etc.) or by installing the pump in a machined manifold that properly represents the engine interface.

3.2.1 A test bed or bench is required to mount the pump and front cover or pump and manifold assemblies. It is strongly recommended that provision be made to test two pump assemblies simultaneously. Current test rigs can only accommodate one large pump (e.g., LGE). The test bed or bench should be enclosed or otherwise shielded. All components should be made from non-corrosive material(s) that can withstand the coolant, temperature and pressure environment of this test, and that are compatible with GM dexcool® coolant. The following features are required.

3.2.1.1 Fume Hood or Vent. Appropriate industry approved construction and performance to prevent accumulation of vapor.

3.2.1.2 Shut-off Provision. Provide shutdown of the equipment in the event that the test conditions exceed specified coolant, temperature and pressure conditions (under or over). Automatic shutdown should occur at the low-end pressure limit and pressure release at the high end.

3.2.1.3 Data Logging System. A computer-controlled system capable of logging coolant temperatures, coolant pressures, coolant flow rates, and pump speeds throughout the course of the test. The parameters for data logging are approximately a temperature range -40°C to 125°C , $\pm 1^{\circ}\text{C}$. The pressure range is -100 kPa to 600 kPa, ± 5 kPa. The flow rate range is 0 Liters per Minute (LPM) to 500 LPM, ± 2 LPM. The speed range is 0 rpm to $10\,000$ rpm, ± 20 rpm. Do not confuse these conditions with those of the diurnal schedule (Appendix B, Table B1).

3.2.1.4 Coolant Circulatory System (Concept versus Reality). Refer to the general schematic located in Appendix A, Figure A1. The system must be capable of producing and maintaining coolant temperatures for the required 24 h cycle residence times (as confirmed at the pump inlet or around the mechanical seal) from -29°C to 115°C minimum for each pump on the test stand.

3.2.1.4.1 Each facility has a different test setup, however they all have these common elements:

- a. Coolant tank capacity, storage temperature and flow control the component test temperature (see 3.2.1.10). This makes temperature control difficult to maintain over time and is why test time at temperature must be extended to meet the minimum number of hours required for the entire 1100 h (see 3.4 Test Time).
- b. There is no environmental chamber surrounding the tested pump(s) to assist temperature control.
- c. The entire coolant storage, delivery and return system must be insulated to avoid temperature loss (warming at the cool end and cooling at the hot end).
- d. Coolant must be constantly circulated (5 rpm to 25 rpm) to avoid temperature drift (e.g., from 12°C to 19°C at the low temperature limit) during the Deep Thermal (DT) cycle.

3.2.1.5 Heated Reservoir Tanks. Tank heater(s) must be of sufficient wattage and in the right tank location to provide a uniform hot coolant. Stirring of stored coolant is highly recommended. Heater to tank capacity must match to deliver a higher coolant temperature in storage to compensate for heat loss to and from the tested pump assembly. Since the existing tank capacities at each lab are different, the heat output requirements are different. However, if the heat exchanger or heater has sufficient capacity to supply sufficiently hot coolant directly, then the tank is not required.

3.2.1.6 Chiller (Cold Reservoir Tank). Tank chiller(s) are needed to obtain the sub-ambient coolant temperatures required by the test. The same requirements apply (e.g., stirring, lower starting storage temperature, etc.) as stated in 3.2.1.5 to **reach and maintain** the minimum required temperature (-29 °C) residence time for each test pump assembly. A pressure vessel to hold coolant for the deep thermal shock segments of the test may be needed if the chiller is incapable of supplying sufficient cold coolant directly. The chiller/reservoir system must be capable of reducing the coolant temperature at the pump inlet from 118 °C to -32 °C.

3.2.1.7 Room Temperature Coolant Reservoir (optional). Test labs have the option of a third reservoir to assist in coolant temperature management.

3.2.1.8 Pressure transducers. Pressure transducers are required to measure the pressures at the inlet and at the outlet of each of the pumps as they are tested.

3.2.1.9 Thermocouples. Thermocouples or other temperature measuring devices are required to measure the coolant temperature as near to the face seal location as possible. At a minimum, the coolant temperature should be measured at the inlet to each of the pumps. See Figure 6 and Glossary 7.1.

3.2.1.10 Flow meters (optional). Two magnetic flow meters can measure the flow rates through each of the pumps as they are tested. A flow monitor (not measure) is useful to confirm adequate flow throughout the coolant delivery and return system.

3.2.1.11 Control System. Control valves, auxiliary pumps, and an automatic control system are required to run this test. The control system must be programmed to change the coolant temperature, pressure, and pump speed, dynamically as described in Appendix B, Table B1, Step 48A test cycle. In addition, there must be a provision to drain coolant from the pump assemblies for the drained-coolant portion of the test. During the drained-coolant portion of the test, the entire system does not need to be drained. It is expected that the pump will be drained of coolant in roughly two minutes. Then the pump is brought up to speed and allowed to run for at least 6 minutes. At the end of the 6 minute drained-coolant run, coolant circulation should be re-established in a maximum of 2 minutes.

3.2.1.12 Air Supply. Either shop air or bottled gas, to perform the Air Leak Test (see 4.1.1). The air supply can also be used to set system pressure.

3.2.1.13 Coolant Filters. The circuit should be flushed and cleaned before starting a test. However, in-line coarse mesh coolant filters are recommended to capture large pieces of any component that fails.

3.2.1.14 Coolant Pumps. One or more pumps are required to properly circulate coolant to achieve the required pressures and maintain temperature. Gear type pumps are more efficient than centrifugal pumps. A line pressure (at the circulation pump return) of 1.4 bar must be constantly maintained to prevent cavitation (coolant vaporization and/or boil over).

3.3 Test Vehicle/Test Piece.

3.3.1 Coolant. Unless otherwise specified, use GM dexcool® coolant concentrate GMW3420 mixed with potable water to a ratio of 60% coolant to 40% water by volume. Pumping coolant during the deep thermal cycling portion of the test is easier with this ratio. There is no coolant change interval during the test. At end of test the coolant is discarded and fresh coolant is mixed for the next test.

3.3.1.1 Monitoring Coolant Concentration. At start of test use an ethylene glycol refractometer to confirm the required coolant/water mix ratio (60/40) percent volume. Addition of coolant and/or potable water is permitted during the test to maintain the nominal concentration within 5%. Checking coolant concentration at end of test is optional, but is required when a pump leak occurs when the test is suspended or ended.

3.3.1.2 Other Coolant Concentrations. GM Brazil has released a 35% concentration/65% potable water mix by volume for factory fill. Twenty-three percent of the 35% concentration is glycerin, the rest is ethylene glycol. *Do not attempt to run this mixture or any other concentration other than 60% organic acid coolant concentration (see 3.3.1) as the lower concentration boiling points under pressure are insufficient for safety.* All the diurnal

Table B1 (Appendix B) measurements and conformance limits are based strictly on the 3.3.1 concentration to GMW3420 approval.

3.3.2 Pump Samples. Use production-intent materials, components, and assemblies. The pumps are to be within the limits of the manufacturing tolerances. The specifications vary for each application and should be obtained from the Release/Validation Responsible Engineer. Specially fabricated parts may be used to achieve any desired tolerance limits. Drill and tap the weep hole as needed to apply air to the weep reservoir for the leak test described in 4.2. Plug any additional holes as needed to seal the pump bore.

3.3.2.1 Roles and Responsibilities for Pump Samples. The Release/Validation Responsible Engineer or Test Requester shall provide the following in a timely manner:

- Provide water pump prints for testing.
- Provide pump inlet and outlet flow rates (liters per minute) from Computational Fluid Dynamics (CFD) analysis or similar engine pumps if the actual pump rates are not available.
- Require dimensional checks on all test elements to verify they meet print requirements.
- Agree with the pump supplier on where to drill the weep hole for air leak testing.
- Establish and test to the minimum installed seal height (mm).
- Agree with the pump supplier on the location and size of the hole for thermocouple and pressure monitoring location close to the mechanical pump seal.
- The pump supplier/test lab shall build the test pump to the conditions in 3.3.2.1, a through g.

3.3.3 Part Cleanliness. All test parts must be clean to production print requirements unless otherwise specified by tester and requester.

3.4 Test Time. Testing must be continued to complete the minimum residence times at temperature for each diurnal cycle.

Calendar time: 14 weeks, nominally, based on 24 h/day run time

Test time: 1100 h (46 cycles at 24 h/cycle)

Coordination time: 14 days to build a typical test setup

3.4.1 Minimum Test Temperature Compliance for Test Setup Qualification. Table 1 represents the required coolant temperature profile at the water pump inlet or close to the mechanical seal. To qualify as capable, a laboratory submits a 24 h data collection test run using the LGE or largest GM water pump of all current production engines. The 5.3.2 test log will be used for reporting data. **During the data reporting process, at no time may test temperatures go beyond the absolute low temperature limits (red column) in non-temperature transition schedule steps.** A test system by location cannot be considered certified and permitted to perform this test until data is submitted to demonstrate Table 1 absolute low temperature limit compliance.

Table 1: Target Temperature Ranges for Equipment Compliance to the Diurnal Schedule

Upper Temperature Control Limit (°C)	Nominal Temperature (°C)	Lower Temperature Control Limit (°C)	Absolute Low Temperature Limit (°C)
-35	-32	-29	-26
+30	+27	+24	+21
+121	+118	+115	+112

3.4.2 GM Global Propulsion Systems (GPS) recognizes the limitations of current equipment, **however it can't certify any system that drifts beyond the required absolute low temperatures in the 24 h cycle for isothermal steps (Table 1, in red column).**

3.4.3 Table 1 sets absolute low temperature target to:

- Establish a robust test capability** because it is an accelerated bench validation test.
- Avoid prolonged extended testing** of the current cycle (3.4) from equipment locations with **wildly varying degrees of time at temperature with little conformance.** Although supplier test equipment is different, we must reduce test performance variation between facilities.
- It sets the bar to know when test equipment reached a meaningful compliance level.**

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3.4.4 Duration Time at Temperature Rules and Requirements. During thermal transition steps in the diurnal schedule in Appendix B (e.g., Steps 46A to 47A, Steps 62A to 1DT, etc.) duration times at temperature are listed for each step. Residence time is where test conditions were able to sustain the required lower temperature control limit, but not for the entire specified duration time. The following sub-paragraphs in 3.4.4 list the requirements for extending the test schedule.

3.4.4.1 During start-up of the first 24 h cycle *DO NOT start the time at temperature until the absolute low temperature (112 °C) is reached. No make-up time is required for Steps 1A through Steps 46A for the first 24 h.*

3.4.4.2 Any record of the time at temperature at or within the Table 1 control limits requires no make-up time.

3.4.4.3 Lost time (referred to as residence time) between the lower temperature control limit and the absolute low temperature limit (Table 1) must be made up by extending the test schedule until all the time (represented by the duration time in minutes) at that temperature is completed. See following Example 2.

3.4.4.4 Make-up Time Management Process. Time is made up **only in the portion of the diurnal schedule where the lost time occurred over the total length of the test (14 weeks).** In the following Example 1, the additional 3.75 days would run only the deep thermal steps including one entry and exit step beyond the DT schedule.

a. **Example 1 – Thermal DT Cycle:** During the 24 h schedule the only lost time was in the DT portion. During the Deep Thermal portion of the test schedule (DT1 to DT33) data showed 307 minutes of 362 minutes/6 h total duration time at temperature was reached. By losing 55 minutes for DT schedule per day, the total make up time over 14 weeks (1100 h) is 5390 minutes/90 h/3.7 days totaling 15 DT cycles.

b. **Example 2 – Isothermal Schedules A and B:** During the 1A to 63A Steps, the total lost time between 115 °C and 112 °C was 15 minutes out of 702 total minutes in a 24 h schedule. The total make-up time over 14 weeks (1100 h) is 1470 minutes/24.5 h/1 day.

During Steps 1B to 30B, the total time lost between 115 °C and 112 °C was 12 minutes out of 328 total minutes in a 24 h schedule. The total make-up time over 14 weeks (1100 h) is 1176 minutes/19.6 h/0.8 day.

c. **Example 3 - Combined Time (A, DT and B).** Combining Examples 1 and 2, one extra 24 h schedule would make-up A and B and 2.7 days or 11 DT consecutive cycles would be run on Step 63A through Step 1B only. This would be the most likely situation based on our test development experience.

3.5 Test Required Information.

3.5.1 A complete list of the part numbers of each component is required. Record the level of components or parts used in the development test, i.e., alpha, beta, etc., the installed height of the seal, air leakage rate, and axial bearing play.

3.5.2 Any other detail related to the test components should be recorded, e.g., if the parts represent the tolerance limit, or a new material, etc. Take photographs of the parts and of the test setup.

3.5.3 Leak Check Frequency. Coolant leakage observations should be made at least once a day and recorded. Test pump inlet temperature and pressure, pump speed, and flow rate, should be logged approximately every 30 s throughout the test. See 5.2 Interpretation of Results.

3.5.4 Deviations. Any test that is not capable of meeting the minimum residence test times at temperature requires a deviation and additional test hours are required to reach the required time at temperature. Deviations are only granted to test equipment with demonstrated compliance (see 3.4.1).

3.6 Personnel/Skills. Technicians (operators) must be experienced in fixture construction. It is an acquired skill learned through application. GM GPS recommends dedicated personnel for this procedure.

4 Procedure

4.1 Preparation.

4.1.1 Air Leak Test.

- Just before starting the test, submerge pump in water.
- Apply air to weep reservoir side of the pump bore starting at atmospheric pressure.
- Increase the air pressure in increments of 25 kPa until 125 kPa is reached.
- Observe and note any air bubbles leaking from seal on the impeller side.

- e. Rotate the shaft at each pressure step (particularly when done at the end of test, rotating the shaft may reduce or eliminate air leaks by seating faces or dislodging any small debris/dried coolant particles that may have entered the seal).
- f. Report the location of any air leaks (between sealing faces, from rubber components, between cartridge and housing, between sleeve and shaft, etc.) No bubbles confirms the contact face portions of the seal are properly seated. If a significant amount of bubbling is observed and continues at higher pressures, install another pump and air test until a satisfactory result is reached.

4.1.2 Fixture. Fabricate a fixture/subassembly to simulate the hydraulic environment of the pump assembly as installed in a vehicle. In some cases, use of the engine front cover may be sufficient. In other cases, where the pump is mounted directly to the engine block, the fixture may have to include the block or a section of the block that has been modified. It is important that the flow geometry immediately upstream and downstream of the pump be recreated in the fixture. The part responsible GM Design Release Engineer (DRE) shall approve that the desired condition is reached.

4.1.2.1 Mechanical Face Seal Boundary Conditions. Setting test condition upper and lower boundary limits is the most effective means of valuating the total population performance. The minimum installed height is set from the stack tolerance conditions of the relevant prints. Testing at maximum installed height is optional.

4.1.3 Preliminary Information. Before running the test, the operator should verify that the preliminary information described in 3.5 and required in 5.3 has been recorded. Identify each water pump assembly with a permanent serial number in an easily visible location.

4.1.4 Fixture Preparation. Install fabricated components or assemblies in the test chamber in the designated vehicle orientation. Changes in orientation must be approved by the part responsible GM DRE. Note the location of each pump in the test stand, including a photograph of the installation.

4.1.4.1 The control valve(s) should be adjusted to provide the required hydraulic resistance in the flow circuit. The Test Requester must specify a flow or inlet and outlet pressure at a specified pump speed. The system pressure should be applied at the tank level.

4.2 Conditions.

4.2.1 Environmental Conditions. Office-type air conditioning should be used to minimize dust, temperature, and humidity. Room temperature must be $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, 20% Relative Humidity (RH) to 90% RH.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

Deviations from the requirements of this standard shall have been agreed upon between test requester and tester.

It is expected that the test maximum pump speed will be adjusted to match the design maximum speed of the pump.

4.2.2.1 Load Limitations of the Test Setup. When testing a water pump, not all the mechanical loads acting on the pump can be reproduced. However, the means used to drive the pump (belt, chain, or gear) should be the same, if possible. The drive mechanism should not introduce any unexpected torsional vibration which may affect the test outcome. Details of the test setup should be reviewed by the GM Cooling Engineer and possibly by the Accessory Drive Engineer.

4.2.2.2 Deviations. A deviation is a test condition that either doesn't represent production intent or fails to evaluate the effect of tolerance variation, fluid hydraulics or flow geometry on pump performance. This is critical when a small number of parts (e.g., 1 or 2 parts) are evaluated for durability. For example, a pump assembly tested as received (without stack tolerance) is a deviation and shall be recorded in the test report. Avoid changes that alter the test correlation.

4.3 Instructions. Note that ramp-up time, actual circulation time, and periods of zero pump speed, are accumulated towards the total test hours (see 5.3.2).

4.3.1 Run the 24 h schedule listed in Appendix B until 1100 h of test time are accumulated (14 weeks total) or until the leakage has exceeded the criteria described in Section 5. The cycle may start any day of the week (Monday through Friday), including weekends. **The test must be extended until all the time at elevated temperature is achieved.**

4.3.2 System Tank Pressures (internal air pressure at top of coolant). The test system storage tank pressure is listed as a footnote in Appendix B as a two part schedule. Since the test setup has two (2) or three (3) tanks, the tank delivering the coolant at that step in the test cycle is pressurized. For the first three days, the system

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pressure is set at 35 kPa. The pressure is then set to 70 kPa for the following three days. This cycle of pressure change occurs every three days for the remainder of the test, in the sequence of 35 kPa to 75 kPa. Coolant system return line pressure at the auxiliary circulation pump be 1.4 bar minimum at all times (see 3.2.1.14).

4.3.3 Visually check for fluid leakage once per day as described in 3.5.

4.3.4 Record any failures/observations (see Section 5: Performance Criteria, and 5.3, Documentation and Report).

4.3.5 Contact the Test Requester for written approval for any deviations to the procedure described (see 4.2.2.1). For example, the test speeds may be scaled down for pumps that will be used on low-speed engines.

4.3.6 Suspension of Test. It may be necessary to suspend a test because of equipment failure, power outage, etc. All suspensions should be documented, and if longer than 24 h should be reported to the Test Requester.

4.3.7 Post-test. Following the completion of the test, complete the air leak test and additional teardown documentation described in 5.3.

5 Data

5.1 Calculations. The performance of the seal is evaluated by considering the total volume of coolant leakage accumulated over the course of the test. Both vapor and liquid leakage should be captured (the condensed vapor contribution is to be taken into account).

5.2 Interpretation of Results (Criteria). Figure 1 shows an example of leakage plotted against cumulative test time. The following conditions define a failure.

5.2.1 If the cumulative leakage **exceeds 100 ml** after 1100 h.

5.2.2 If the mean leakage rate **exceeds a maximum of 9.1 ml/100 h at any time during the test**, even if the cumulative leakage is not greater than 100 ml. This is illustrated as Example B in Figure 1. (Note that the cumulative leakage criterion is effectively included within the leakage rate criterion, i.e., the leakage rate limit must be exceeded in order to obtain more than 100 ml after 1100 h).

5.2.2.1 Coolant leakage may be continuously monitored by removing the pump cup plug and allowing any coolant passing through or around the mechanical seal to collect in a graduated cylinder. Record the collection time consistent with 5.2 requirements. Make sure no uncollected coolant is trapped between the pump and the graduate cylinder.

5.2.3 Report damage to the elastomeric elements (5.3.3.12), especially the bellows as shown in Figure 4, Photos 1 through 6. Report on any other condition suggesting onset of failure (e.g., excessively soft, tacky surface). Report evidence of internal porosity as an action item for tracking source process controls (see Photo 7).

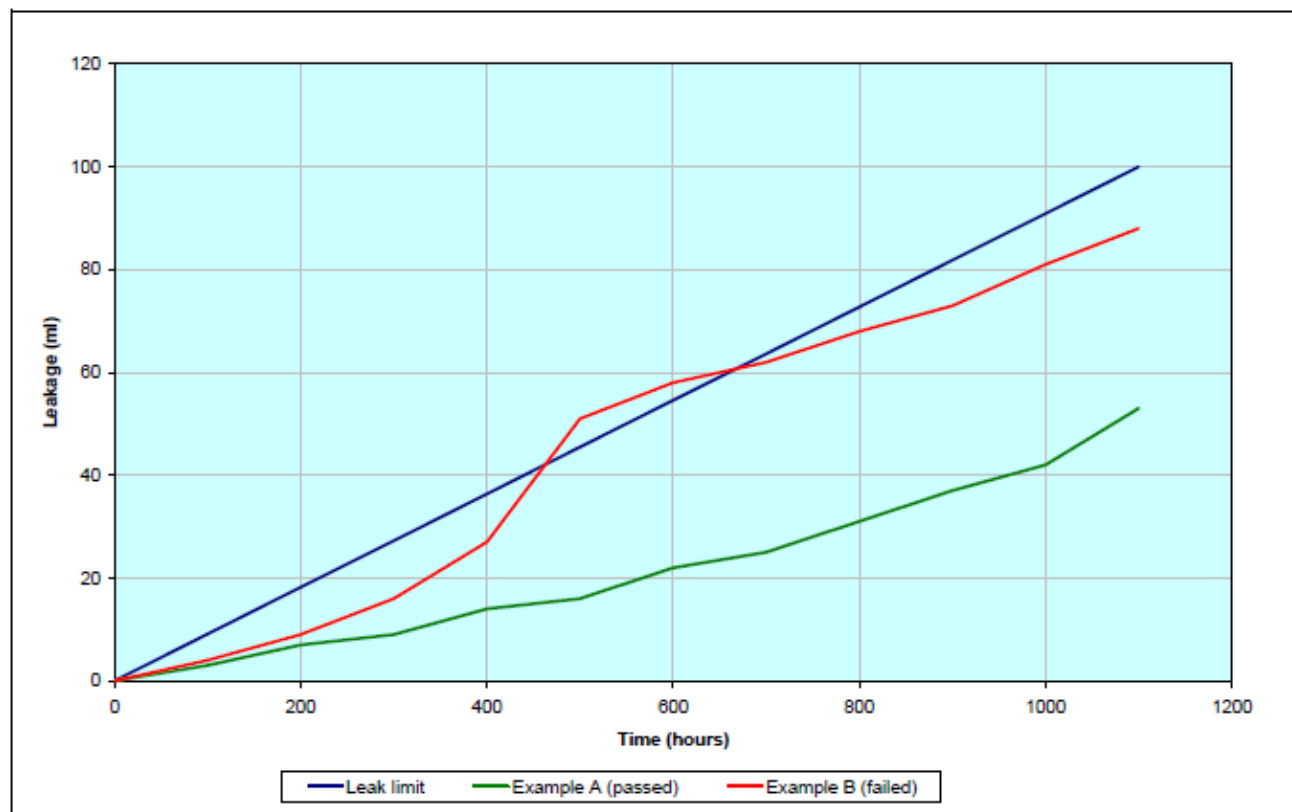


Figure 1: Durability Leak History

5.3 Test Documentation. A report should be prepared at the end of the test with that contains the following information.

5.3.1 General Pump Information. Relevant print tolerances, part identification, photographs of test setup and subassembly, installation height of the seal (4.1.2.1), air leak test results before and after the test, bearing axial play before and after the test.

5.3.2 Test Details. Logged data of the measured pressures and temperatures, daily (or more frequent) observations for fluid leakage, any un-usual other conditions in the room environment due to utility interruption or construction, changes or modifications during test. On daily or weekly reporting do not use Okay (OK), a check mark or other non-descriptive response. Proper responses verify to the reader a check was performed, e.g., "No leak found upon inspection". The evaluator's name or initials must accompany each observation. If a leak is reported, note the location, time and action taken. Use the header format example in worksheet shown in Table 2 and include the 24 h diurnal steps in the far left column and a drop down list to simplify data search.

Table 2: Worksheet Reporting Header (with drop down feature) Example

SEGMENT	SPEED (RPM)	HOT TANK TEMP (°C)	ROOM TEMP TANK (°C)	COLD TANK TEMP (°C)	OUTLET TEMP (°C)	VOLUME TEMP (°C)	HOT TANK PRESSURE (BAR)	ROOM TEMP TANK PRESSURE (BAR)	COLD TANK PRESSURE (BAR)	VOLUME PRESSURE (BAR)	VOLUME PRESSURE (KPa)	OUTLET PRESSURE (BAR)	OUTLET PRESSURE (KPa)	INLET PRESSURE (MPa)	INLET PRESSURE (KPa)	sec.	SECONDS	MINUTES	HOURS
1A)	750	114.58	23.66	-32.21	112.3	113.2	1.05	0.97	0.97	1.18	118	1.23	123	1134	113.4	1252.7	0	0	0
1A)	750	114.69	23.55	-32.31	112.4	113.1	1.05	0.97	0.97	1.11	111	1.16	116	1128	112.8	1258.3	5.6	0.093333333	0.0015556

5.3.2.1 Electronic Data Review. After start of test, technicians must confirm the temperature transition and residence times immediately after the first 24 h cycle. If not in compliance, the test is **shutdown or red tagged as non-compliant requiring immediate corrective action noting date and time** and the condition corrected before proceeding to end of test. The Test Technician shall notify the GM component Responsible Engineer, Test Requestor and/or GM Global Propulsion Systems Sealing Technical Specialist when non-compliant transition occurs. Any non-compliant temperature transition cycles reviewed by data collection are not counted as test time and must be made-up. Continue to review data at one week intervals for compliance to required test conditions.