



SURFACE VEHICLE RECOMMENDED PRACTICE

J3210™

NOV2022

Issued

2022-11

Low-Speed Continuous Slip Durability Test

RATIONALE

This SAE Recommended Practice addresses the need for a standardized test procedure to evaluate the friction characteristics of the wet clutch system (WCS) at various pressures, speeds, and temperatures, and measures how the friction characteristics change with aging during a durability cycle.

1. SCOPE

This SAE Recommended Practice is intended as the definition of a standard test, which may be subject to frequent change to keep pace with experience and technical advances. This should be kept in mind when considering its use.

This SAE No. 2 friction test monitors the μ -v curve for a negative slope which can be used to evaluate a wet clutch system (WCS) anti-shudder performance and can be used for any wet driveline mechanism. WCS shudder is considered a clutch failure condition. The cause of shudder is consistent with glazing as the primary failure mode. It has been shown that a substantial loss of the wet friction material surface porosity leads to a glaze forming on the friction material surface. This process typically leading to a negative $d\mu/dv$ slope over time as addressed in SAE 2020-01-0560.

This procedure includes evaluation friction characteristics of wet clutch system (WCS) at various specific pressures, speeds, and temperatures, and an extended durability duty cycle test to evaluate the WCS during which the μ -v curve is monitored for a negative slope—a condition indicating the potential for shudder.

This procedure can be used to compare the shudder potential of various WCS combinations of friction material and lubricant. It is recommended that testing be conducted on an SAE No. 2 or similar machine. Also use the same machine for all tests when comparing results. The amount of aging has not been correlated to vehicle mileage or vehicle shudder and should only be used as an example of a test that results in a severe negative slope on the μ -v test.

This procedure is designed for a standard SAE plate clutch pack with one friction plate and two steel plates, but can be modified for any WCS configuration.

This procedure is built on the basis of SAE J2964, with modified test parameters and test procedure to evaluate a WCS aging stability and predict anti-shudder performance.

This procedure is intended as a recommended practice for both suppliers and end users.

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2022 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J3210_202211

For more information on this standard, visit
https://www.sae.org/standards/content/J3210_202211/

Documents

Document Sharing Hub

The only variables selected by the supplier or user of the friction system are:

- Friction plate with friction material (lining): Specify friction material, lot or batch number, groove pattern, and lining thickness.
- Fluid: Specify fluid and lot or batch number.
- Reaction (separator) plates: Use SAE standard as indicated below. Specify plates material, thickness, and lot or batch number.

These three variables must be clearly identified when reporting the results of this test. If any of the test parameters or system hardware as described in this document are changed—other than the friction material, test fluid, or reaction (separator) plates—the data may not be reported as being obtained using this document, but should be shown as a modified version of the procedure.

The friction testing has a combination of modes, including short time continuous slip (C), ramp up and down speed sweeps (S), and static or breakaway slip (BA). The friction testing is done before break-in (BBI), after break-in (ABI), and after each aging test block (A). The general overview this test procedure is presented schematically in Figure 1.

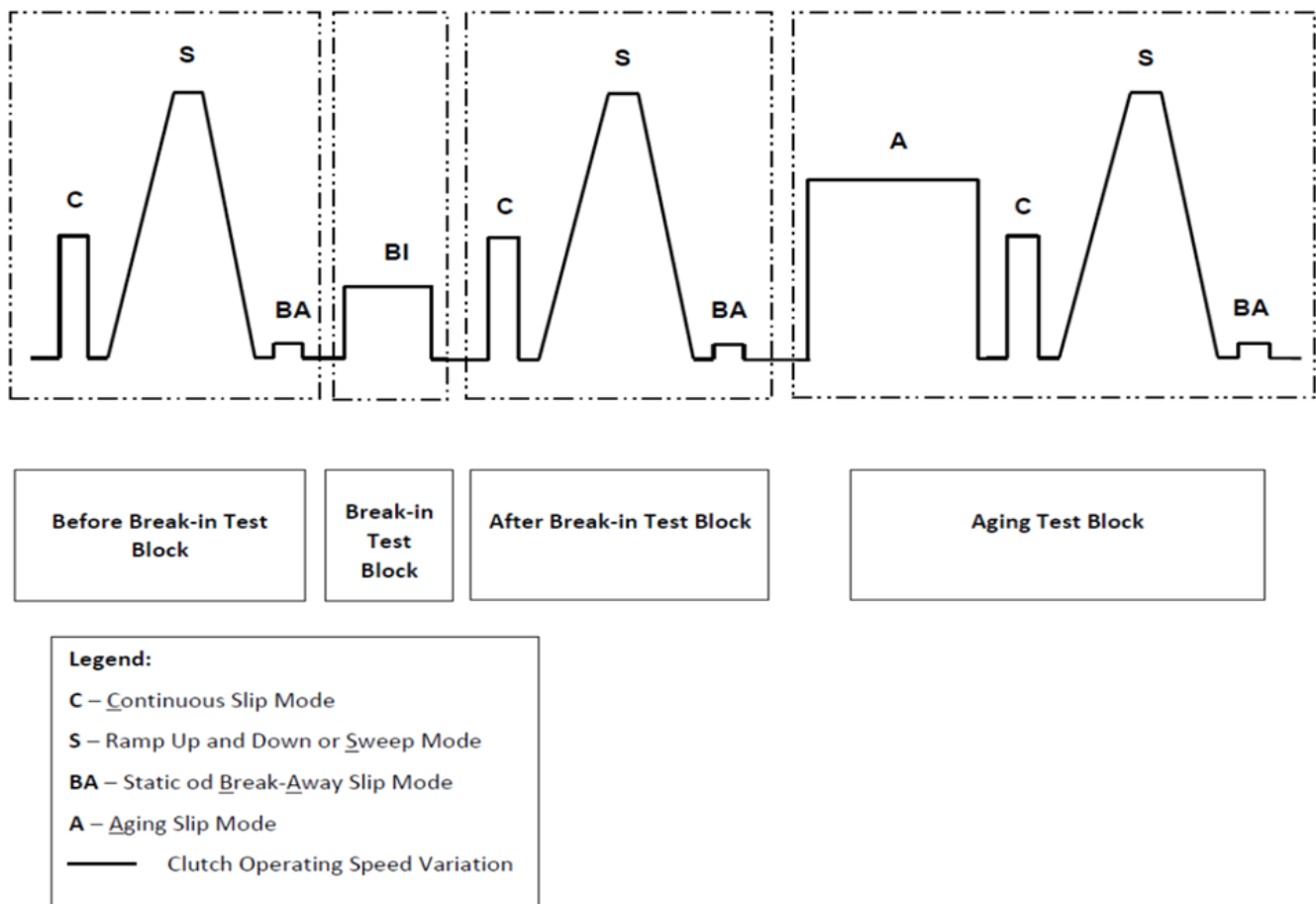


Figure 1 - Test schematic - test blocks sequence

Reference the testing clutch geometric parameters are shown in Table 1.

Table 1 - Clutch pack geometric parameters
(Per SAE J2490.)

Parameter	Symbol	Unit	Value
Lining outside diameter	OD	m	0.14615
Lining inside diameter	ID	m	0.12055
Lining effective radius	R _e	m	0.06688
Lining surface area/surface, gross	A _g	m ²	0.00536
Number of friction surfaces	n _f	#	2
Apply piston area	A _p	m ²	0.01511
Assumed friction coefficient	μ	-	0.130

Various testing speeds, fluid temperatures, unit surface pressures, and slip timings are used during the different modes to simulate clutch operating conditions.

The aging mode test parameters are selected to accelerate the WCS degradation response within the 120 hours total time. The obtained values of friction torque and resulting friction coefficient, friction coefficient slopes (gradients), fluid, and reaction plate temperatures allow comparison of the WCS wear resistance and resistance to aging. These parameters are utilized for evaluating the clutch anti-shudder performance.

Details of the test modes operating conditions are presented in Section 5.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J286	SAE No. 2 Clutch Friction Test Machine Guidelines
SAE J1646	Glossary of Terms - Lubricated Friction Systems
SAE J2490	SAE No. 2 Friction Test Machine μPVT Test
SAE J2964	Low-Speed Continuous Slip SAE No. 2 μPVT Procedure

Morgan, C., Fewkes, R., McCombs, T., Tersigni, S. et al., "Low-Speed Carbon Fiber Torque Capacity and Frictional Properties Test for ATFs," SAE Technical Paper 2004-01-3026, 2004, <https://doi.org/10.4271/2004-01-3026>.

Diemer, L., Bares, J., Greening, B., Ezanno, P. et al., "Testing Wet Clutch Systems for Anti-Shudder Performance," SAE Technical Paper 2020-01-0560, 2020, <https://doi.org/10.4271/2020-01-0560>.

Ohtani, H., Zreik, K., Steigerwald, E., Knaffel, M. et al., "Shudder and Frictional Characteristics Evaluation of Dual Clutch Transmission Fluids," SAE Technical Paper 2014-01-1988, 2014, <https://doi.org/10.4271/2014-01-1988>.

Noles, J., Watts, R., Ishikawa, M., and Saito, H., "Test Methods for Determining Anti-Shudder Durability of Automatic Transmission Fluids," SAE Technical Paper 2007-01-1974, 2007, <https://doi.org/10.4271/2007-01-1974>.

2.1.2 JSAE Publications

Available from Society of Automotive Engineers of Japan (JSAE), 10-2 Gobancho, Chiyoda-Ku, 102-0076 Japan, Tel: +81-3-3262-8211 <https://www.jsae.or.jp/en/>.

JASO M349-2012 Test Method for Anti-Shudder Performance of Automatic Transmission Fluids

JASO M348-2012 Road Vehicles - Automatic Transmission Fluids - the Friction Characteristic Test Method

3. TEST EQUIPMENT

3.1 Test Machine

A SAE No. 2 friction test machine with low-speed (300 rpm) drive or other test machine having adequate capabilities is applied for this test. Because machine design characteristics can have a significant effect on test results, users are advised to use caution when comparing results obtained on machines of different design. The standard test will be SAE No. 2 machine or equivalent with $\varnothing 190$ mm standard test head and apply air pressure piston area of 0.01511 m^2 . If a non-standard SAE No. 2 machine is used, the type shall be noted in the test report.

3.2 Data Acquisition

At not less than 1000 samples per second and storage system with at least six channels with response as follows:

- Torque channel: Bandwidth 500 Hz, accuracy shall be within $\pm 0.5\%$ of full range.
- Apply pressure channel: Bandwidth 500 Hz, accuracy shall be within $\pm 0.5\%$ of full range.
- Speed channel: Bandwidth 500 Hz, accuracy shall be within $\pm 0.25\%$ of full range.
- Test fluid temperature channel: Bandwidth 3 Hz, accuracy shall be within $\pm 0.75\%$ of full range.
- Front reaction plate temperature channel: Bandwidth 50 Hz, accuracy shall be within $\pm 0.75\%$ of full range.
- Rear reaction plate temperature channel: Bandwidth 50 Hz, accuracy shall be within $\pm 0.75\%$ of full range.

For digital data systems, the data is to be recorded at a minimum of 1000 samples per second per channel using 15 ms time constant RC filter.

3.3 Test Fluid System

Test requires only 700 mL of the testing fluid inside the test head reservoir to cover the clutch pack plates. Adding or topping off of the fluid is not permitted.

3.4 Adapters and Reaction Plates

Adapters for an SAE No. 2 friction test machine including reaction plates, hub, retainer, pressure plate, and spacers are all described in Appendix A of SAE J2490. Other machines would use adapters suited to that machine. Sketch of assembled test head with clutch is shown in Figure 2.

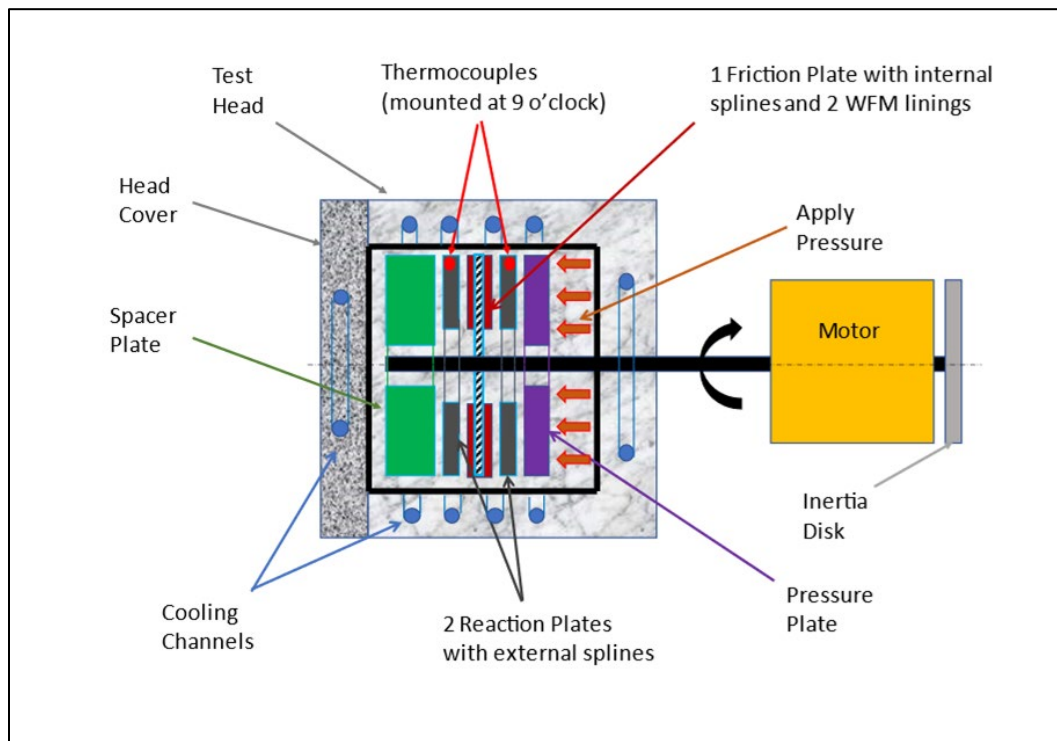


Figure 2 - Sketch of test head with clutch pack, top view
 (Republished with permission from SAE Technical Paper 2020-01-0560. © 2020 SAE International.)

3.5 Apply Piston

A silicon compound seal is recommended for use with this high temperature fluid.

3.6 Test Parts

- 3.6.1 The required parts are SAE No. 2 friction plate with core as item 6 of SAE J2490, Appendix A, and the mating steel reaction plate also known as separator plate as item 5 of SAE J2490, Appendix A.
- 3.6.2 The plate orientation is the same as SAE J2964, Figure B3, Appendix B.
- 3.6.3 The test can also be performed with the reaction plate's orientation as the round edge (due to the stamping process) is faced to the friction material surfaces of the friction plate. See Figure C1, Appendix C (which is the same as JASO M348-2012, Figure 6).
- 3.6.4 Total clutch pack clearance at mounting in the test head shall be $0.75 \text{ mm} \pm 0.15 \text{ mm}$ as indicated in SAE J2964.

3.7 Fluid and Plates Thermocouples

- 3.7.1 Fluid temperature inside the test head is measured at 7 o'clock with a thermocouple.
- 3.7.2 Reaction plate temperatures are measured at 9 o'clock by a thermocouple is inserted in each of two reaction plates and positioned in the middle of the plate thickness and on the depth equal of the effective radius of the friction material. For details of the thermocouple hole drill, see Figure B2, Appendix B. The second thermocouple on each reaction plate installed at 3 o'clock may be required (optional).

4. TESTING SURFACE MEASUREMENT AND OBSERVATION

4.1 Observation Plates

Before the test and after the test, the steel plates and friction plates should be measured and inspected.

- 4.1.1 During inspection before test, any abnormalities such as pits, scorings on the steel plate, loss of material, or texture abnormalities for the friction plates must be reported and a determination of usage be made.
- 4.1.2 During inspection after test, any abnormalities observed on the steel plates such as hot spots, scorings, scuffings, cracks, or warping, and on the friction plate as glazing or loss/wear on friction material must be reported.

4.2 Plates Thickness Measurement

- 4.2.1 Thickness of clutch pack, each steel plate, and friction plate before and after test must be reported.
- 4.2.2 For thickness of clutch pack, measurement in four places after soak must be reported. The spline of each clutch pack should be marked so that the measurements are taken in the same position pre- and post-test.

4.3 Plates Roughness Measurement

- 4.3.1 Roughness of steel plates before and after test must be reported per a print provided.
- 4.3.2 Roughness of friction plate before and after test should be reported per a print provided. For an example of such appearance, refer to item 6 of SAE J2490, Appendix A.

4.4 Optional Information

- 4.4.1 Photographs of the steel plates and friction plate before and after test may be required (optional).
- 4.4.2 Fluid samples for oil analysis taken before and after test may be required (optional).

5. TEST OPERATING CONDITIONS AND TEST PARAMETERS

The test procedure contents four test blocks sequence: before break-in (BBI), break-in, after break-in (ABI), and aging test blocks. Schematic representation of each test block is shown in Figures 3, 4, and 5.

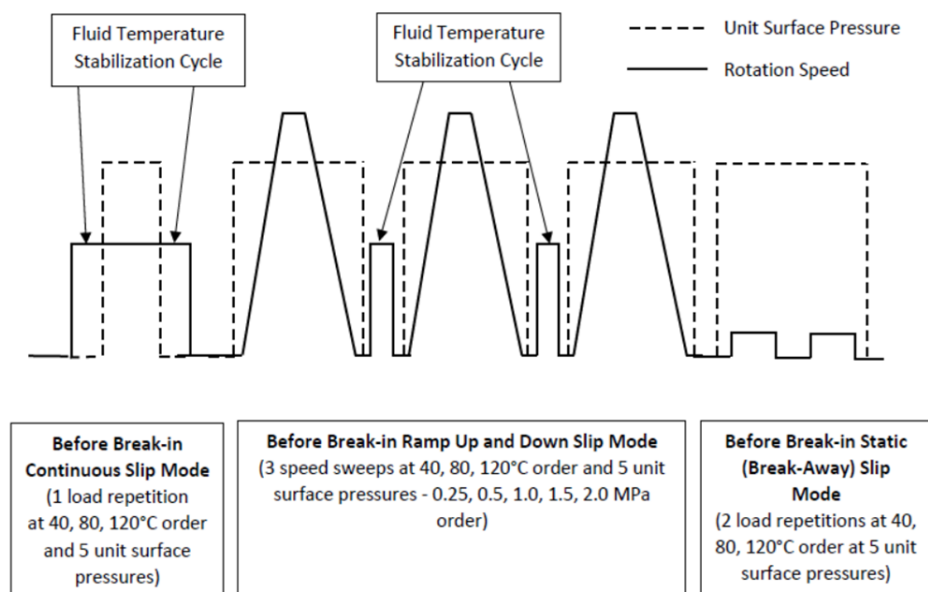


Figure 3 - Test schematic - BBI test block and test modes sequence

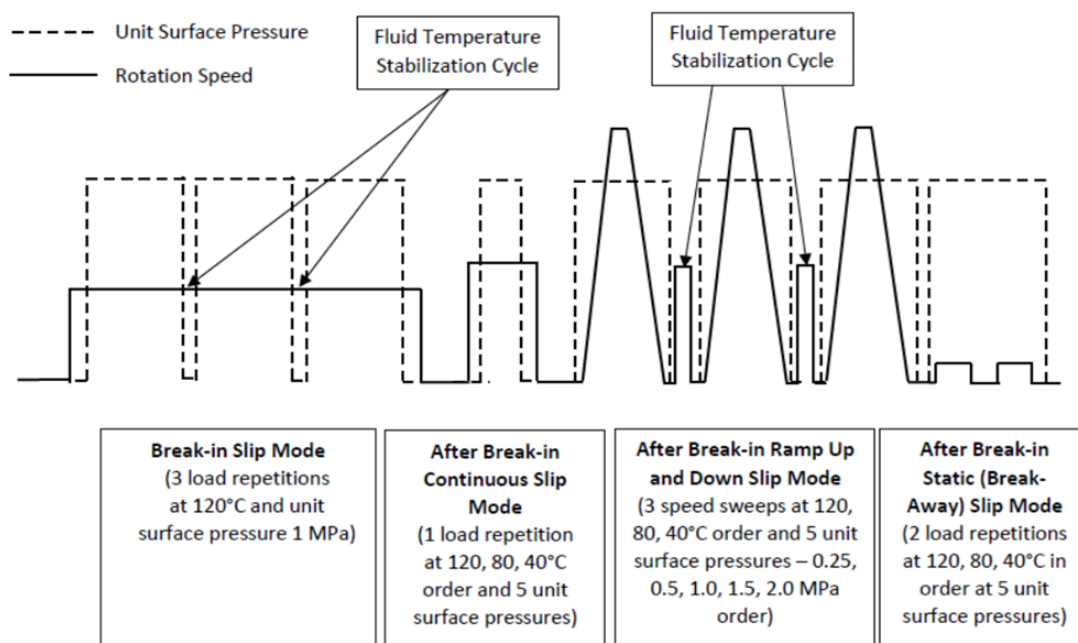


Figure 4 - Test schematic - break-in and ABI test blocks and test modes sequence

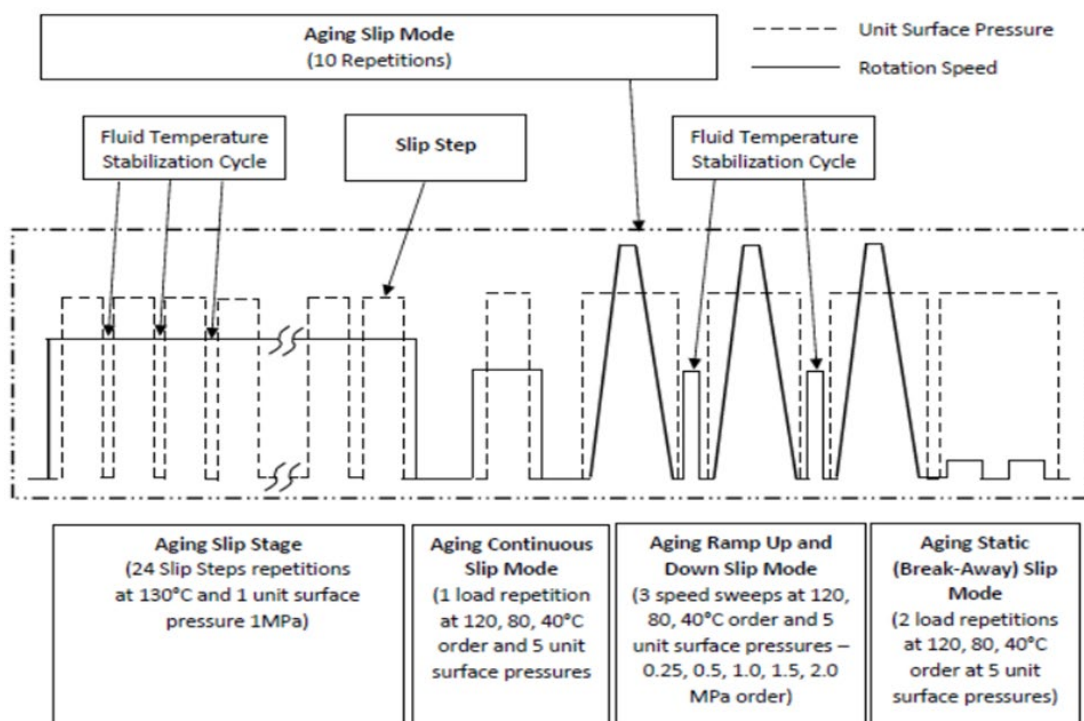


Figure 5 - Test schematic - aging test block and test modes sequence

Test operating parameters are shown in Tables 2 and 3.

Table 2 - Loading parameters applied

Parameter	Formula	Symbol	Unit	A	B	C	D	E
Apply pressure		P_p	kPa	89	177	355	532	710
Apply force	$P_p \cdot A_p$	F_a	N	1341	2681	5362	8043	10725
Gross unit surface pressure	F_a/A_g	p_g	MPa	0.25	0.50	1.00	1.50	2.00
Engagement torque	$n_r \cdot F_a \cdot \mu \cdot R_e$	τ	N·m	23.3	46.6	93.2	140	187

Table 3 - Operating rotation speeds applied (for $Re = 0.06688 \text{ m}$)

Test Mode Speed	rpm	m/s
Static breakaway slip	4.3	0.03
Continuous slip	100	0.70
Upper ramp slip	258	1.80
Break-in slip	86	0.60
Aging slip	129	0.90

5.1 Temperature Stabilization Cycle

This cycle allows the bulk fluid and clutch plates to regain temperature equilibrium.

- Fluid temperature sequence at BBI slip mode: 40 °C, 80 °C, and 120 °C.
- Fluid temperature sequence at ABI mode and aging slip mode: 120 °C, 80 °C, and 40 °C.
- Maintain time: 1 minute after attaining target temperature ± 3 °C.
- Rotational speed: 100 rpm (0.7 m/s) per Table 3.
- Unit surface pressure: 0 MPa (clutch open).

5.2 Continuous Slip Mode

This mode starts before the ramp up and down slip mode at each test fluid temperature and each unit surface pressure applied.

This mode's content is the same for all test blocks.

- Slip speed: 100 rpm ± 1 rpm (0.7 m/s) per Table 3.
- Stabilize the speed: 1 second.
- Fluid temperature sequence at BBI slip mode: 40 °C, 80 °C, and 120 °C.
- Fluid temperature sequence at ABI mode and aging slip mode: 120 °C, 80 °C, and 40 °C.
- Apply clutch unit surface pressure sequence: 0.25 MPa, 0.5 MPa, 1.0 MPa, 1.5 MPa, and 2.0 MPa, $\pm 3\%$ MPa.
- Duration: 3 seconds ± 0.05 second on each unit surface pressure sequence.
- Ramp time to achieve pressure: 0.2 to 0.25 second.
- Data recording: 1000 Hz.