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Road vehicles — Brake lining friction materials — Product definition and quality assurance

Véhicules routiers — Matériaux de friction pour garnitures de freins — Définition du produit et assurance qualité

Reference number
ISO 15484:2008(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15484 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 2, *Braking systems and equipment*.

Introduction

Drum and disc brake friction materials are important functional parts of the wheel brakes. They are pressed against the rotating brake drum or disc by a clamping force applied by the actuating mechanism of the brake during a braking operation. The kinetic energy of the vehicle is thereby largely transformed into heat. The brake pad or lining is of essential importance for the effectiveness and user comfort of the brake system. Disc brake pads consist of the friction material itself, the pad carrier plate and, in some cases, silencing parts, pad wear warning devices and retaining or guiding elements. The friction material is usually permanently bonded to the backing plate by a bonding process in which the friction material is subjected to both heat and pressure. Underlayers can be inserted between the friction material and backing plate to improve bond strength and other properties. Drum brake linings consist of the friction material itself, usually shaped to match the radius of the brake shoe onto which it is subsequently attached. The friction material is usually attached to the supporting brake shoe either by bonding or by the use of rivets. Conventional friction materials consist mainly of fibrous materials, bonding agents, anti-seize agents, metals and other fillers. The friction material type, and any backing plates, anti-noise measures, pad springs and pad wear warning devices, etc., are defined in the relevant figure.

The basic aim of this International Standard is:

— to ensure the product is verified and validated during all project phases for transfer into series production;

— to increase product reliability and at the same time limit the cost of testing;

— to identify the necessary test standards to equally cover brake performance and noise.

Visibility of production spread and the opportunity to select parts for testing from assorted areas of compressibility are the main reasons for the statistical evaluation. The procedures described in this International Standard are based on ISO/TS 16949 and encompass the entire product quality preplanning process, from the definition phase up to the determination of parameters for series production. These are defined in this International Standard as phases 1 to 7.

Road vehicles — Brake lining friction materials — Product definition and quality assurance

1 Scope

The procedures in this International Standard apply to disc brake pads and drum brake linings for motor vehicles and describe systematic processes for the quality assurance of such brake linings.

In conjunction with tolerance ranges, the test methods and results described in this International Standard permit a rapid assessment of disc brake pads.

Uniform handling of the procedures through various phases ensures that the quality assurance requirements are clearly understood and that a global implementation is possible in the relationship between customers and suppliers.

This International Standard relates to the completed friction material and is applicable during product development to the quality assurance of ongoing series production, focussing on the “component” friction material. It is advisable that tests with apparent “system” character be avoided.

Raw material checks and processing control are outside the scope of this International Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2812-1, *Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water*

ISO 6310, *Road vehicles — Brake linings — Compressive strain test method*

ISO 6312, *Road vehicles — Brake linings — Shear test procedure for disc brake pad and drum brake shoe assemblies*

ISO/PAS 22574, *Road vehicles — Brake linings friction materials — Visual inspection*

ISO 26865, *Road vehicles — Brake lining friction materials — Standard performance test procedure for commercial vehicles with air brakes*

ISO 26866, *Road vehicles — Brake lining friction materials — Standard wear test procedure for commercial vehicles with air brakes*

ISO 26867, *Road vehicles — Brake lining friction materials — Friction behaviour assessment for automative brake systems*

ISO 27667, *Road vehicles — Brake lining friction materials — Evaluation of corrosion effects on painted backing plates and brake shoes*

JASO C458-86, *Test procedure of pH for brake linings, pads and clutch facings of automobiles*

JIS D 4311, *Clutch facings for automobile*

JIS D 4421, *Method of hardness test for brake linings, pads and clutch facings of automobiles*

SAE J2598, *Automotive disc brake pad natural frequency and damping test*

SAE J2694, *Anti-noise shims: T-Pull test* [1)]

SAE J2707, *Wear test procedure on inertia dynamometer for brake friction materials*

SAE J2724, *Measurement of disc brake friction material underlayer distribution*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
density
ρ
ratio of the mass to the volume of the friction material under normal conditions

3.2
porosity
P
relative volume proportion of cavities in a material

NOTE This includes open or enclosed pores of any size, shape and distribution.

4 Symbols and abbreviated terms

Symbol	Definition	Unit
ρ	density	g/cm^3
ρ_{net}	absolute or real density without pore volume	g/cm^3
m_a	pad mass in air for density measurements	g
m_w	pad mass in water for density measurements	g
V	pad volume for density measurements	cm^3
P	porosity	%
T_R	room temperature	°C
p_B	brake pressure	kPa
M_d	torque	Nm
W_B	pad wear	mm/g
W_s	disc wear	mm/g
μ	coefficient of friction	—

1) In preparation.

5 Product quality preplanning and test plan

5.1 General

The test requirements for the various phases are defined in the different test plans for passenger cars and commercial vehicles in 5.4.

The development phase of prototypes (phases 1 to 4) describes the systematics and tests used in the manufacture of brake linings from tools not yet meeting series standards. The end of phase 4 is the technical product release.

The production transfer and initial sampling (phases 5 and 6) describes the required scope of testing for the assessment of the initial production series with the tools and processes intended for the series.

The validation of the manufacturing process is proven by documentation and assessment of the results during initial series production (phase 6).

The test volume during the continuing series production monitoring (phase 7) lies within the responsibility of the pad manufacturer and is documented in the control plan (CP) which also includes the details for the in-process inspection as well as for the incoming inspection of purchased parts like raw materials, backing plates, shims and accessories.

Based on the level of in-process controls, the test efforts on the final product should be minimized and some tests, such as friction tests, may not be needed for each single batch. In any case, the frequency and sample size has to be defined in the CP.

The chemical-physical brake lining data of the tests listed below include performance and/or characteristic data which result from a process chain. Any requirements of process capability indices and statistical process control need to be agreed between the customer and the supplier. Agreed tolerances, however, have to be respected.

5.2 Procedure

5.2.1 General procedure

The approval of brake linings is made by vehicle testing and a concurrent determination of its properties by the test standards listed here.

The manufacturer of brake linings ensures that the parameters, the composition and the monitoring of the specified process parameters are maintained by regulated and auditable procedures.

The determination of performance data via the test standards listed here at the end of this process chain and comparison with the tolerance serves as confirmation that the prescribed procedures were correctly performed.

The time delay between processing and testing does not permit process intervention such as SPC (statistical process control).

Determination of performance data on completed brake linings during a batch test serves as continuing proof of conformity and permits the observation of trends.

The tolerance range for these data is determined as described in 5.2.2 to 5.2.5 below.

5.2.2 Prototyping — Customer samples (phase 4)

Initial specification of tolerances are determined from the values of the batch tests of the prototype sampling. The assessment takes account of the data of the variant then approved. The tolerances arising from the approved prototypes are registered in the lining data sheet (LDS).

5.2.3 Specification/validation (phases 5 and 6)

Results are obtained from the batches of the product transferred to series production, under the condition that the composition, the process, the brake, disc or drum and geometry are determined and comply with the state of the series. The results are verified with the customer. Variations to the tolerances shall be agreed with the customer and results shall be recorded on the lining data sheet (LDS). Specifications of tolerance are agreed with the customer viewing the data, using statistical analyses as appropriate.

5.2.4 Series monitoring (phase 7)

The ongoing surveillance of the series production (phase 7) shall be in accordance with the test frequencies and sample size which are fixed in a control plan by the manufacturer based on the process controls on series production.

5.2.5 Review of tolerance

A review of the tolerance following a number of batch tests to be determined can be performed by the friction material manufacturer and the customer.

5.3 Phases of product quality preplanning

The phases of product quality preplanning are shown in Figure 1.

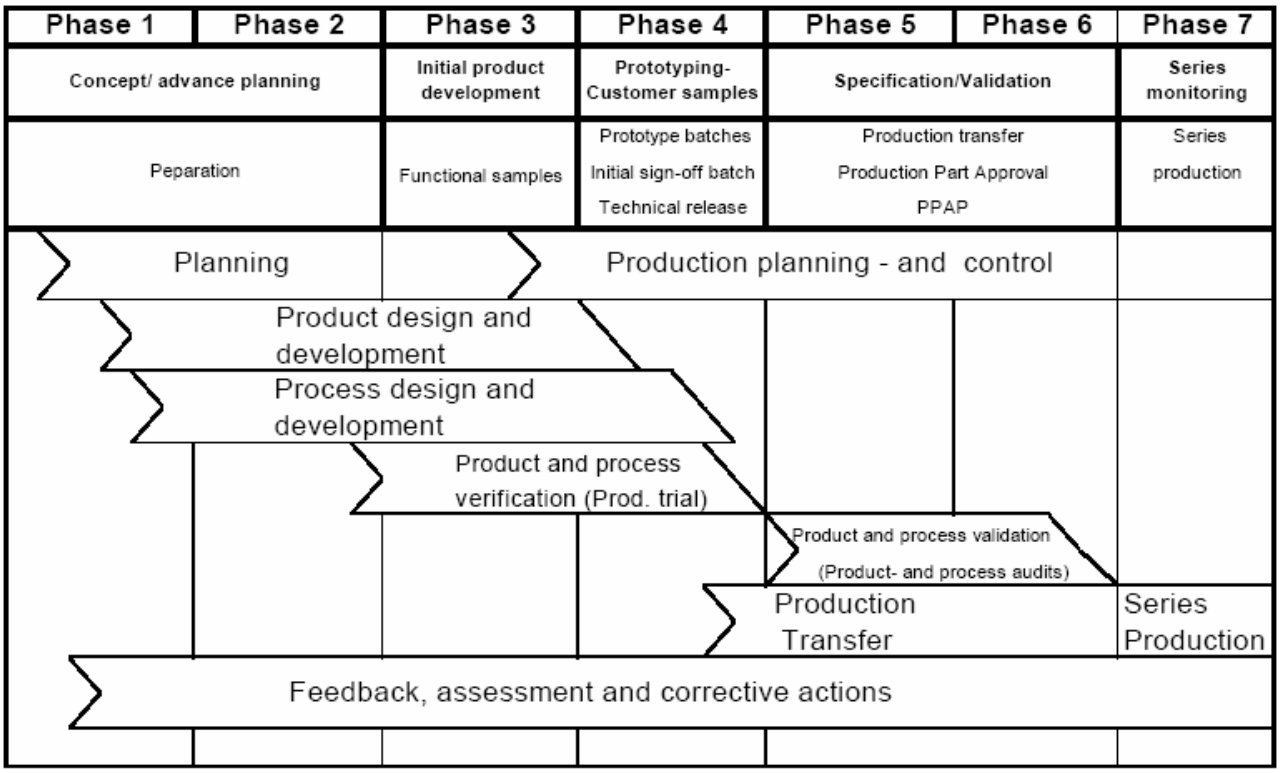

Figure 1 — Phases of product quality preplanning

5.4 Test plan

5.4.1 General

Separate test plans are made for passenger cars and commercial vehicles. The test plans differentiate four basic categories of tests:

a) general;

b) physical properties;

c) corrosion;

d) inertia dynamometer tests.

This International Standard defines preferred test procedures. Because of established databases and practices, alternative and regional tests are accommodated in the test plans. The companies working in another region should respect local practices. The future goal is the complete harmonization of the test procedures.

5.4.2 Test plan for passenger car disc brake pads

The test plan for passenger car disc brake pads is shown in Figure 2.

Test plan for passenger car disc brake pads					Phase 1 / 2	Phase 3	Phase 4			Phase 5 + 6		Phase 7
					Concept / advance planning	Initial product development	Prototyping - Customer samples			Specification/ Validation		Series monitoring
Type of tests	**Notes**	**Standard/ Document**	**Index**	**Kick-off Meeting**	Preparation	Functional samples	Prototype batches	Initial sign-off batch	**Technical release**	Production transfer	**Production Part Approval**	Series production
General												
visual inspection		ISO/PAS 22574	**D**			100%	100%	100%		100%		**C**
underlayer distribution		SAE J2724	**D**			3/3	3/3	3/3		3/3		
inspection critical dimensions		Part drawing	**D**			2/2	5/5	5/5		5/5		**C**
full dimensional inspection	**1**	Part drawing	**D**							5/5		
Physical Properties												
density		ISO 15484	**E**			3	3	3		3		
porosity		ISO 15484	**E**			3	3	3		3		
pH-Index		JASO C458-86	**E**			3	3	3		3		
compressibility, cold	**2**	ISO 6310	**A, D**			50/50	50/50	50/50		50/50		**C**
compressibility, hot		ISO 6310	**D**			2/2	2/2	5/5		5/5		
swell and growth 1		ISO 6310	**D**			2/2	2/2	5/5		5/5		
thermal transmission		ISO 6310	**D**			2/2	2/2	5/5		5/5		
shear strength, cold		ISO 6312	**A, D**			5/5	5/5	5/5		5/5		**C**
shear strength, cold (after performance dyno test)		ISO 6312				1/1	1/1	3/3		1/1		
T-pull-test (bonded insulator)		SAE J2694	**D**			2/2		2/2		2/2		**C**
eigenfrequency		SAE J2598	**D, G**				3/3	3/3		3/3		
Alternative/regional tests												
swell and growth 2 (oven)		SAE J160	**D**			2/2	2/2	2/2		2/2		
hardness	**2**	JIS D4421	**A, D**			50/50	50/50	50/50		50/50		**C**
Corrosion												
corrosion effects on painted backing plates & shoe	**3**	ISO 27667	**E, F**							1 x 3		
resistance to brake fluid and mineral oil	**3**	ISO 2812-1	**E, F**							1 x 3		
Inertia-dynamometer tests												
performance test 1/ production friction test		ISO 26867	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B / C**
wear test	**3**	SAE J2707	**D, H**				1 Br. Set	1 Br. Set		1 x 1 Br. Set		**B**
Alternative/regional tests												
performance test 2		SAE 2522	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
performance test 3		JASO C-406	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
production friction test		ECE R 90/Annex 8	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**C**
Optional Inertia-dynamometer tests												
noise matrix dyno test		SAE J2521	**D**				1 Br. Set	1 Br. Set		1 Br. Set		
						Results of each batch				each Batch		
Description:						**LDS**	**LDS / MSDS**			**LDS**		**LDS**
				Technical Requirements		**Friction Material Specification**				**Parameter fixing**		**Drawing**

LDS Lining Data Sheet
MSDS Material Safety Data Sheet

Index:

A The values so designated are to be shown as a trend representation starting from phase 5
B Within a Product audit as per manufacturer's control plan
C Frequency and sample size as manufacturer´s control plan
D Tests with new linings from each part number
E Tests with new linings from inner or outer side
F General process/machine tests with new linings from inner or outer side (n/n), not for each part number
G All pads for noise dyno tests
H Selection of wear test option in agreement with customer

Notes:

1 Full dimensional inspection only for PPAP (initial sampling)
2 Evaluation of statistical distribution; samples for further tests to be derived from statistical distribution
3 1 test during production transfer, primarily the first batch

Remarks:

Test quantities are valid for each part number ! Separate for inner and outer pads.
PPAP (Initial sampling) could be in-between or after Phase 5+6.
The a.m. sampling quantities are the sufficient requirements. For prototypes, the sample can be reduced if there is a proven shortage of parts.
For repeated sampling also tests can be left out, e.g. SAE J2707 wear testing.
The complete test plan applies to new products or to friction material changes in existing products.

Figure 2 — Test plan for passenger car disc brake pads

5.4.3 Test plan for passenger car drum brake linings/lined shoes

The test plan for passenger car drum brake linings/lined shoes is shown in Figure 3.

Test plan for passenger car drum brake linings/lined shoes					Phase 1 / 2	Phase 3	Phase 4			Phase 5 + 6		Phase 7
					Concept / advance planning	Initial product development	Prototyping - Customer samples			Specification/ Validation		Series monitoring
Type of tests	**Notes**	**Standard/ Document**	**Index**	**Kick-off Meeting**	Preparation	Functional samples	Prototype batches	Initial sign-off batch	**Technical release**	Production transfer	**Production Part Approval**	Series production
General												
visual inspection		ISO/PAS 22574	**D**			100%	100%	100%		100%		**C**
inspection critical dimensions		Part drawing	**D**			3/3	5/5	5/5		5/5		**C**
full dimensional inspection	**1**	Part drawing	**D**							5/5		
Physical Properties												
density		ISO 15484	**D**			3/3	3/3	3/3		3/3		
porosity		ISO 15484	**D**			3/3	3/3	3/3		3/3		
pH-Index		JASO C458-86	**D**			3/3	3/3	3/3		3/3		
hardness		JIS D4421	**A, D**			3/3	3/3	5/5		5/5		**C**
shear strength, cold	**2**	ISO 6312	**A, D**			3/3	3/3	5/5		5/5		**C**
shear strength, cold (after performance dyno test)	**2**	ISO 6312				1/1	1/1	3/3		1/1		
Alternative/regional tests												
gogan hardness		SAE J379	**A, D**			3/3	3/3	5/5		5/5		**C**
Corrosion												
corrosion effects on painted backing plates & shoe	**3**	ISO 27667	**E**							1 x 3		
resistance to brake fluid and mineral oil	**3**	ISO 2812-1	**D**							1 x 3		
Inertia-dynamometer tests												
performance test 1/ production friction test		ISO 26867	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B / C**
wear test	**3**	SAE J2707	**D, F**				1 Br. Set	1 Br. Set		1 x 1 Br. Set		**B**
Alternative/regional tests												
performance test 2		SAE 2522	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
performance test 3		JASO C-406	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
production friction test		ECE R 90/Annex 8	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**C**
Optional Inertia-dynamometer test												
noise matrix dyno test		SAE J2521	**D**				1 Br. Set	1 Br. Set		1 Br. Set		
						Results of each batch				each Batch		
						LDS	**LDS / MSDS**			**LDS**		**LDS**
				Technical Requirements		**Friction Material Specification**				**Parameter fixing**		**Drawing**

Description:

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A The values so designated are to be shown as a trend representation starting from phase 5
B Within a Product audit as per manufacturer's control plan
C Frequency and sample size as manufacturer´s control plan
D Tests with new linings from each part number
E General process/machine tests with new lined shoes, not for each part number
F Selection of wear test option in agreement with customer

Notes:

1 Full dimensional inspection only for PPAP (initial sampling)
2 If applicable
3 1 test during production transfer, primarily the first batch

Remarks:

Test quantities are valid for each part number !
PPAP (Initial sampling) could be in-between or after Phase 5+6.
The sampling quantities stated for brake linings are the minimum requirement. For prototypes, the sample can be reduced if there is a proven shortage of parts.
For repeated sampling also tests can be left out, e.g. SAE J2707 wear testing.
The complete test plan applies to new products or to friction material changes in existing products.

Figure 3 — Test plan for passenger car drum brake linings/lined shoes

5.4.4 Test plan for commercial vehicle disc brake pads

The test plan for commercial vehicle disc brake pads is shown in Figure 4.

Test plan for commercial vehicle disc brake pads					Phase 1 / 2	Phase 3	Phase 4			Phase 5 + 6		Phase 7
					Concept / advance planning	Initial product development	Prototyping - Customer samples			Specification/ Validation		Series monitoring
Type of tests	**Notes**	**Standard/ Document**	**Index**	**Kick-off Meeting**	Preparation	Functional samples	Prototype batches	Initial sign-off batch	**Technical release**	Production transfer	**Production Part Approval**	Series production
General												
visual inspection		ISO/PAS 22574	**D**			100%	100%	100%		100%		**C**
underlayer distribution		SAE J2724	**D**			3/3	3/3	3/3		3/3		
inspection critical dimensions		Part drawing	**D**			2/2	5/5	5/5		5/5		**C**
full dimensional inspection	**1**	Part drawing	**D**							5/5		
Physical Properties												
density		ISO 15484	**E**			3	3	3		3		
porosity		ISO 15484	**E**			3	3	3		3		
pH-Index		JASO C458-86	**E**			3	3	3		3		
compressibility, cold		ISO 6310	**A, D**			5/5	5/5	5/5		5/5		**C**
compressibility, hot		ISO 6310	**D**			2/2	2/2	5/5		5/5		
swell and growth 1		ISO 6310	**D**			2/2	2/2	5/5		5/5		
thermal transmission		ISO 6310	**D**			2/2	2/2	5/5		5/5		
shear strength, cold		ISO 6312	**A, D**			5/5	5/5	5/5		5/5		**C**
shear strength, cold (after performance dyno test)		ISO 6312				1/1	1/1	3/3		1/1		
Alternative/regional tests												
swell and growth 2 (oven)		SAE J160	**D**			2/2	2/2	2/2		2/2		
hardness (alternative to compressibility)		JIS D4421	**A, D**			5/5	5/5	5/5		5/5		**C**
Corrosion												
corrosion effects on painted backing plates & shoe	**2**	ISO 27667	**E, F**							1 x 3		
resistance to brake fluid and mineral oil	**2**	ISO 2812-1	**E, F**							1 x 3		
Inertia-dynamometer tests												
performance test 1/ production friction test		ISO 26865	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B / C**
wear test 1	**2**	ISO 26866	**D, H**				1 Br. Set	1 Br. Set		1 x 1 Br. Set		**B**
Alternative/regional tests												
performance/ wear test 2		SAE J2115	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
performance test 3		JASO C-407	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
wear test 3	**2**	SAE J2707	**A, D**				1 Br. Set	1 Br. Set		1 x 1 Br. Set		**B**
production friction test		ECE R 90/Annex 8	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**C**
						Results of each batch				each Batch		
Description:						**LDS**	**LDS / MSDS**			**LDS**		**LDS**
				Technical Requirements		**Friction Material Specification**				**Parameter fixing**		**Drawing**

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E Tests with new linings from inner or outer side
F General process/machine tests with new linings from inner or outer side (n/n), not for each part number
G All pads for noise dyno tests
H Selection of wear test option in agreement with customer

Notes:

1 Full dimensional inspection only for PPAP (initial sampling)
2 1 test during production transfer, primarily the first batch

Remarks:

Test quantities are valid for each part number ! Separate for inner and outer pads.
PPAP (Initial sampling) could be in-between or after Phase 5+6.
The sampling quantities stated for brake pads are the minimum requirement. For prototypes, the sample can be reduced if there is a proven shortage of parts.
For repeated sampling also tests can be left out, e.g. SAE J2707 wear testing.
The complete test plan applies to new products or to friction material changes in existing products.

Figure 4 — Test plan for commercial vehicle disc brake pads

5.4.5 Test plan for commercial vehicle drum brake linings

The test plan for commercial vehicle drum brake linings is shown in Figure 5.

Test plan for commercial vehicle drum brake linings					Phase 1 / 2	Phase 3	Phase 4			Phase 5 + 6		Phase 7
					Concept / advance planning	Initial product development	Prototyping - Customer samples			Specification/ Validation		Series monitoring
Type of tests	**Notes**	**Standard/ Document**	**Index**	**Kick-off Meeting**	Preparation	Functional samples	Prototype batches	Initial sign-off batch	**Technical release**	Production transfer	**Production Part Approval**	Series production
General												
visual inspection		ISO/PAS 22574	**D**			100%	100%	100%		100%		**C**
inspection critical dimensions		Part drawing	**D**			3/3	5/5	5/5		5/5		**C**
full dimensional inspection	**1**	Part drawing	**D**							5/5		
Physical Properties												
density		ISO 15484	**E**			3	3	3		3		
porosity		ISO 15484	**E**			3	3	3		3		
hardness		JIS D4421	**A, D**			3/3	3/3	3/3		3/3		**C**
swell and growth 1		ISO 6310	**D**			2/2	2/2	2/2		2/2		
thermal transmission		ISO 6310	**D**			2/2	2/2	2/2		2/2		
strength		JIS D 4311	**A, D**			1/1	2/2	2/2		2/2		**C**
Alternative/regional tests												
compressibility (cold/hot)		ISO 6310	**A, D**			2/2	2/2	2/2		2/2		**C**
swell and growth 2 (oven)		SAE J160	**D**			2/2	2/2	2/2		2/2		
gogan hardness		SAE J379	**A, D**			3/3	3/3	3/3		3/3		**C**
Inertia-dynamometer tests												
performance test 1/ production friction test		ISO 26865	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B / C**
wear test	**2**	ISO 26866	**D, G**				1 Br. Set	1 Br. Set		1 x 1 Br. Set		**B**
Alternative/regional tests												
performance/ wear test 2		SAE 2115	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
performance test 3		JASO C-407	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**B**
wear test 3		SAE J2707	**A, D**				1 Br. Set	1 Br. Set		1 Br. Set		**B**
production friction test		ECE R 90/Annex 8	**A, D**			1 Br. Set	1 Br. Set	3 Br. Set		1 Br. Set		**C**
						Results of each batch				each Batch		
Description:						**LDS**	**LDS / MSDS**			**LDS**		**LDS**
				Technical Requirements		**Friction Material Specification**				**Parameter fixing**		**Drawing**

LDS Lining Data Sheet
MSDS Material Safety Data Sheet

Index:
A The values so designated are to be shown as a trend representation starting from phase 5
B Within a Product audit as per manufacturer's control plan
C Frequency and sample size as manufacturer´s control plan
D Tests with new linings from each part number
E Tests with new leading or trailing segments or anchor or cam block
G Selection of wear test option in agreement with customer

Notes:
1 Full dimensional inspection only for PPAP (initial sampling)
2 1 test during production transfer, primarily the first batch

Remarks:

Test quantities are valid for each part number !
PPAP (Initial sampling) could be in-between or after Phase 5+6.
The sampling quantities stated for brake linings are the minimum requirement. For prototypes, the sample can be reduced if there is a proven shortage of parts.
For repeated sampling also tests can be left out, e.g. SAE J2707 wear testing.
The complete test plan applies to new products or to friction material changes in existing products.

Figure 5 — Test plan for commercial vehicle drum brake linings

6 Checks and requirements — Brake lining complete

6.1 General (visual, dimensional and material checks)

6.1.1 Visual inspection

Brake linings shall exhibit no faults which could impair their function. The brake linings are inspected in the "as supplied" condition. The characteristic features for the visual inspection are defined in ISO/PAS 22574.

6.1.2 Underlayer distribution

The test method shall be in accordance with SAE J2724.

6.1.3 Dimensions

The dimensions of the brake linings which are to be tested shall comply with the appropriate current part drawing.

6.1.4 Material

The brake lining manufacturer shall ensure and document the uniformity of material quality. The batch data of the approved initial samples are taken as a reference for all production batches.

Potential test procedures in addition to raw material test results and certificates can be:

— thermogravimetric analysis (TGA);

— thermomechanical analysis (TMA);

— pyrolytic gas chromatography (PGC);

— differential-scanning-calorimetry (DSC);

— electronic-differential-X-ray (EDX).

This list does not exclude other test techniques.

The material of the pad backing plate, the insulating shim, the retaining spring and the pad wear warning device shall comply with relevant drawing instructions.

6.2 Physical properties

6.2.1 Density

6.2.1.1 Method of determination

The density of friction materials is determined by the water displacement method. The procedure is based on the Archimedes principle. This states that a body fully immersed in water will exhibit an apparent loss of mass equivalent to the mass of the displaced water. Because 1 cm^3 of water weighs one gram at 4 °C, the loss of mass in water can be regarded as a numerical value equivalent to the volume. The density is therefore equal to the quotient of the mass in air and the mass of the displaced water.

The test method in accordance with JIS D 4417 may be used as an alternative.

6.2.1.2 Apparatus

A suitable underfloor weigher, by means of which the mass of the sample can be weighed in grams within a tolerance of 0,1 % and to whose weighing facility a thin wire, light wire basket or clasp can be attached without any adverse effects on the result.

A water vessel in a size which allows the sample to be completely immersed in the water, without coming into contact with the bottom or side walls of the vessel.

6.2.1.3 Sample preparation

The friction material can be used wholly or in part for determining the density.

Cut-out parts should have a minimum mass of 5 g. Rough surfaces shall be flat and smooth, to prevent the formation of bubbles when immersed in water. Care shall be taken that the samples are free from possible underlayer or bonding residue.

6.2.1.4 Procedure

The test is carried out at a temperature of (23 ± 2) °C. The water used is free from any suspended particles. Approximately 0,01 % of a wetting agent is added to the water in the water vessel in order to reduce its surface tension. If the water is visibly contaminated, it shall be replaced.

First, the mass of the sample in air (m_a) shall be determined. Then the sample shall be completely immersed into the water by means of a wire, in a light wire basket, or using a clasp, and in the water its mass (m_w) shall be measured following an immersion period of 10 s. Ensure that no air bubbles adhere to the sample.

6.2.1.5 Calculation

The density, ρ, is calculated as follows:

$$\rho \cong \frac{m_a}{m_a - m_w}$$

$$\rho = \frac{m_a}{V}$$

$$V = \frac{m_a - m_w}{\rho_{water}} \quad (1)$$

where

m_a is the pad mass in air;

m_w is the pad mass in water;

V is the pad volume.

6.2.1.6 Test report

State the density figure for each product as a single numerical value to the nearest 0,01 g/cm^3. If portions (parts) of a pad are measured, the average of three sample results shall be taken as the density of the product.

6.2.2 Porosity

6.2.2.1 Method of determination

The measured density of the friction material is compared to the calculated density. The measured density is based on either the specific gravity of the sample or dimensional measurements to determine the sample volume and mass. The calculated density is based on the density of each of the brake lining components and the mass proportion in the formulation.

The test method in accordance with JIS D 4418 may be used as an alternative.

6.2.2.2 Sample preparation

If the sample volume is to be determined by dimensional measurements, it shall be ground with flat parallel sides which allow acceptable thickness, length and width measurements to the nearest 0,1 % of the nominal sizes.

6.2.2.3 Procedure

6.2.2.3.1 Inspect the part for adequate grind.

6.2.2.3.2 Measure the sample length, width and thickness, each to the nearest 0,1 %.

6.2.2.3.3 Measure the mass of the sample to the nearest 0,1 %.

6.2.2.3.4 Obtain the real density and the mass percentage of each raw material in the formulation. Do not include any fugitive materials such as solvents.

6.2.2.4 Calculation

The porosity, P, is calculated as follows:

$$P = \left(1 - \frac{\rho}{\rho_{\text{net}}} \right) \times 100\,\% \tag{2}$$

where

ρ is mass/(length × width × thickness);

ρ_{net} is the absolute or real density without pore volume, calculated from a weighted average of the real density of the pad lining components.

6.2.2.5 Test report

Report porosity to the nearest 0,1 %.

6.2.3 pH-index

The test method shall be in accordance with JASO C458-86.

6.2.4 Cold and hot compressibility

The test method shall be in accordance with ISO 6310.

6.2.5 Swell and growth

The test method shall be in accordance with ISO 6310.

The test method in accordance with SAE J160 may be used as an alternative/regional test.

6.2.6 Thermal transmission

The test method shall be in accordance with ISO 6310.

6.2.7 Shear strength

The test method shall be in accordance with ISO 6312.

6.2.8 T-pull test (bonded insulator)

The test method shall be in accordance with SAE J2694.

Constant cross-head speed is an alternative to constant ramp load.

6.2.9 Eigenfrequency

The test method shall be in accordance with SAE J2598.

6.2.10 Strength

The test method shall be in accordance with JIS D 4311.

6.2.11 Alternative regional tests

6.2.11.1 Hardness (alternative regional test for cold compressibility)

The test method shall be in accordance with JIS D 4421.

6.2.11.2 Gogan hardness

The test method shall be in accordance with SAE J379.

6.3 Corrosion (backing plate and shoe surface treatment)

The corrosion resistance of the backing plate coating of disc brake pads and the coating of lined shoes shall be tested in accordance with ISO 27667 and ISO 2812-1.

The coating thickness is stated in the drawing or specification.

6.4 Friction performance passenger cars

6.4.1 General

The inertia-dynamometer test programme describes the friction value behaviour of a friction material with regard to the influences of pressure, temperature and speed. Its main purpose is to compare friction materials under the most equal conditions possible. To take account of the different cooling behaviours of the different test stands, the fading series are temperature-controlled. Project-related brakes and brake discs shall be used.

6.4.2 Inertia-dynamometer tests

6.4.2.1 Performance test 1/Production friction test

The test method shall be in accordance with ISO 26867.

6.4.2.2 Wear test

The test method shall be in accordance with SAE J2707.

6.4.3 Alternative regional tests

6.4.3.1 Performance test 2

The test method shall be in accordance with SAE J2522.

6.4.3.2 Performance test 3

The test method shall be in accordance with JASO C406-00.

6.4.3.3 Production friction test

The test method shall be in accordance with UNECE Regulation No. 90 (2001), Annex 8 (Determination of friction behaviour by machine testing). Suitable substitutes can be used instead of an original brake calliper, disc and drum for prototype purposes. For the initial sample release and later, original components shall be used. If several variants are possible per vehicle, the most thermally stressed brake disc/drum shall be used. The brake disc/drum may be reworked. Note minimum thickness in accordance with the manufacturer's instructions.

If a test result is found to be outside the limits, the test shall be repeated twice. If the negative result is confirmed, an alternative dynamometer test shall be made by agreement with the customer. If the final check confirms the friction behaviour to be unsatisfactory, the brake linings shall be taken out of circulation.

6.4.4 Optional inertia-dynamometer test: Noise matrix dyno-test

The test method shall be in accordance with SAE 2521.

6.5 Friction performance commercial vehicles

6.5.1 General

The inertia-dynamometer test programme describes the friction value behaviour of a friction material with regard to the influences of pressure, temperature and speed. Its main purpose is to compare friction materials under the most equal conditions possible. To take account of the different cooling behaviour of the different test stands, the fading series are temperature-controlled. Project-related brakes and brake discs shall be used.

6.5.2 Inertia-dynamometer tests

6.5.2.1 Performance test 1/production friction test

The test method shall be in accordance with ISO 26865.

6.5.2.2 Wear test 1

The test method shall be in accordance with ISO 26866.

6.5.3 Alternative regional tests

6.5.3.1 Performance/wear test 2

The test method shall be in accordance with SAE J2115.

6.5.3.2 Performance test 3

The test method shall be in accordance with JASO C407-00.

6.5.3.3 Wear test 3

The test method shall be in accordance with SAE J2707.

6.5.3.4 Production friction test

The test method shall be in accordance with UNECE Regulation No. 90 (2001), Annex 8 (Determination of friction behaviour by machine testing). Suitable substitutes can be used instead of an original brake calliper, disc and drum for prototype purposes. For the initial sample release and later, original components shall be used. If several variants are possible per vehicle, the most thermally stressed brake disc/drum shall be used.

The brake disc/drum may be reworked. Note minimum thickness in accordance with the manufacturer's instructions.

If a test result is found to be outside the limits, the test shall be repeated twice. If the negative result is confirmed, an alternative dynamometer test shall be made by agreement with the customer. If the final check confirms the friction behaviour to be unsatisfactory, the brake linings shall be taken out of circulation.

7 Documentation in the lining data sheet (LDS)

The test results determined as above shall be documented in a lining data sheet (see example in Annex A).

The test results up to phase 6 are used to establish specification limits which will thereafter form a mandatory standard for the brake lining manufacturer.

8 Ongoing production monitoring

If a test result is outside the specification, the batch shall be taken out of circulation unless a deviation is agreed by the customer.

Annex A
(informative)

Example of lining data sheet (LDS)

A.1 General

A lining data sheet with the values entered by the supplier shall be attached to the initial sample report.

A.2 Identification of the lining

LDS status: **Drawing No.:**	**Issue:** **Issue:**	**Date:** **Date:**	
Customer:	**Vehicle:**	**Brake:**	
Brake disc size:	**Brake disc manufacturer:**		
Pad manufacturer:	**Friction material:**	**Pad area on backing plate:** **Pad surface area:**	**cm^2** **cm^2**
Backplate manufacturer:	**Shim/Type:**	**Manufacturing site:**	
Manufacturing method. Single/multiple chamber:			

A.3 Visual inspection in accordance with ISO/PAS 22574

Remark:

A.4 Underlayer distribution in accordance with SAE J2724

	Prototype results **min./max./average**	**Production transfer results** **min./max./average**	**Product specification** **min./max./average**

A.5 Dimensional inspection in accordance with drawing (for details see initial sampling report)

Remark:

A.6 Physical properties

Characteristic	Prototype results min./max./average	Production transfer results min./max./average	Product specification min./max./average
Density g/cm^3 **ISO 15484**			
Porosity % **ISO 15484**			
pH value **JASO C458-86**			
Eigenfrequency **SAE J2598**			
T-pull test **SAE J2694**			
Hardness **JIS D 4421**[a]			

[a] Alternative regional test for cold compressibility.

A.7 Compressibility and thermal transmission in accordance with ISO 6310

Characteristic	Prototype results min./max./average	Production transfer results min./max./average	Product specification min./max./average
Compressibility, cold µm			
Compressibility, hot µm			
Thermal transmission °C			

A.8 Swell and growth in accordance with ISO 6310 [(regional) alternative SAE J160]

Characteristic	Prototype results min./max./average	Production transfer results min./max./average	Product specification min./max./average
Swell and growth mm			

A.9 Shear strength in accordance with ISO 6312

Characteristic	Prototype results min./max./average	Production transfer results min./max./average	Product specification min./max./average
Shear force N			
Bonding in core zone %			
Bonding in edge zone %			

A.10 Corrosion test in accordance with ISO 27667 and ISO 2812-1

Corrosion test/coating	Requirement	Specification	Pass/fail	
Cross-cut test	⩽ Gt 1	ISO 27667		
Coat thickness µm				
Guide surfaces µm				
Other surfaces				
Salt spray test (Procedure SS)	24 h	ISO 27667		
Degree of blistering	⩽ Ri 1	ISO 27667		
Degree of rusting	⩽ m1/g1	ISO 27667		
Degree of cracking	⩽ 2 mm	ISO 27667		
Resistance to brake fluid and mineral oil	8 h	ISO 2812-1		

A.11 Performance test 1/production friction test in accordance with ISO 26867

Characteristics	Prototype results min./max.	Production transfer results min./max.	Product specification min./max.

A.12 Wear test in accordance with SAE J2707

Characteristics	Prototype results min./max.	Production transfer results min./max.	Product specification min./max.

A.13 Remarks

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