



Engine Accessory Drive Low Modulus Cord Belt

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 standard covers supplier requirements for low modulus cord engine accessory drive belts.

1.2 Applicability. This standard contains all information necessary to design, analyze, develop, validate, and manufacture accessory drive low modulus cord belts.

1.3 Remarks. This standard covers only low modulus cord belts. There are two (2) other accessory drive belt specifications that cover normal polyester/aramid cord belts, GMW16242, and high load/torque belts, GMW16328.

2 References

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

2.1 External Standards/Specifications.

ACEA A3/B3	DIN 70070	ISO 22241	SAE J2236
ASME Y 14.5M	ISO 1431-1	SAE J1459	SAE J2432
ASTM D3395			

2.2 GM Standards/Specifications.

GMW3059	GMW16242	GMW16328
GMW3232	GMW16290	

2.3 Additional References.

- Johnson Matthey Testing and Development; 12600 Universal Drive, Taylor, Michigan, 48180

3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. Backing must be smooth, and free of "texture".

3.1.2 Content.

3.1.2.1 Physical Content. Belt consists of three basic layers: rib, cord and backing, with an adhesion layer at the cord line or an additional rib surface layer on some constructions. Construction details are at the discretion of the supplier, but must result in meeting the requirements of this specification.

3.1.2.1.1 S Twist and Z Twist Cords. In order to decrease sensitivity of the belt to tracking in the direction of the cord twist, it is required that the belt be constructed with alternating cords with S twist and Z twist (see Appendix A, Figure A2) There is no intent to exclude other approaches to eliminating belt tracking error, but any proposal would require Technical Specialist approval.

3.1.2.1.2 Backside Material. Only rubber backed belts are recommended with fiber reinforcement to stabilize the cord layer, and to improve backside abrasion. The visual appearance of the backside must be smooth and free of proud imperfections, blemishes, etc., as seen in reflected overhead light. For the purpose of establishing a visual standard, these imperfections, in some cases, may not exceed 0.05 mm proud or depressed from the backside surface.

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On sensitive applications and definitely on molded belt applications, a butt splice on all rubber belt layers will be a requirement. Note that understanding of this requirement will be generated from samples of belts from each supplier which represent unacceptable quality. New blemish conditions will arise as a function of time, and the Technical Specialist will determine acceptability of same.

3.1.2.1.2.1 Pattern. Use of a pattern on the backside of the belt is not recommended, and would require the approval of the Release Engineer as well as the Technical Specialist. It is not to be used as a normal design feature. Rubber backed belts are to be used as the feature to achieve any backside surface characteristic which may address specific application issues.

3.1.2.1.2.2 Backside Labels. On some applications, it is required to control the step in the backside surface to < 0.05 mm maximum by either printing the label or either pre or post curing ink from a very thin transfer film, or by use of an ink backing that is compatible with the belt and which will remain as part of the belt after cure. All label proposals require Technical Specialist approval.

3.1.2.1.3 Backside Builder/Banner/Bias Laps. It is required to control backside steps including end of roll splices to within 0.05 mm on some applications. In all cases, build and banner splices must not occur at the same place on the belt. The dimension of these features is not practical to measure in production on an ongoing basis but the process must be demonstrated as capable over volume production prior to Production Part Approval Process (PPAP) approval. Butt splices may be required on some applications and definitely on molded belts. This same requirement applies to displacement of the cord line due to overlaps. This is to be measured with the belt under a tension of 100 N/rib. (The cord will straighten, and a backside bump will appear for measurement.)

3.1.2.2 Functional Content.

3.1.2.2.1 Low Modulus Cord Belt Functional Design. In order to provide function, low modulus cord belts must demonstrate stable load over their lifetime. In order to prove this design function, the following must be demonstrated by bench testing prior to approval for durability testing.

3.1.2.2.2 Load Break In. Low modulus (polyamide is usually the material chosen) cord has some unique characteristics that limit its application as a cord material. The first of these is a significant drop in tension when the belt is first produced. In order to understand this effect, the following test must be run on at least six (6) belts, and then in production on one (1) belt for each sleeve produced.

- Place the belt on a two-pulley fixture using the SAE J1459 belt length measurement pulleys at the nominal application belt length at room temperature.
- Rotate the belt at 4500 rpm for 3 minutes or until stabilization while recording load.
- Final load is to be measured at low rotational speed without stopping the belt from the previous test step.
- Approval of the precise procedure (speed and time) with each supplier by the Technical Specialist will depend upon the available equipment and the break-in behavior of the belt.

3.1.2.2.3 Load Stability. It is difficult to achieve stability of the belt load as a function of time after break-in. In order to establish acceptable stability to $\pm 5\%$ load, or as otherwise specified, over the life of the belt, load must be measured and reported on all test belts at the nominal length for the application, and to stabilization after break-in, and then after every durability test in this specification.

3.1.2.2.4 Load as a Function of Temperature. Polyamide (or equivalent for function) cord may not behave linearly with temperature (like polyester or aramid cord) after treatment to provide shrinkage with increasing temperature. It is required that broken-in belt load be measured at the nominal length as a function of temperature from -40 °C to 125 °C on a rotating rig. The object is to define the inflection point of stretch to shrinkage. In other words, the belt will stretch or not change length with temperature up to a limit, and after that, shrink with increasing temperature. Worst case for design is that limit, so it must be established.

3.1.2.2.5 Low Modulus Definition. Low modulus is defined as one-third ($\frac{1}{3}$) of the modulus of a polyester cord belt. This level of stiffness has been proven to address the functional issues with accessory drive dynamic issues. It is fixed to provide like performance between suppliers so that, whatever supplier is sourced, that function will be maintained.

3.1.3 Ambient Environment. Varies by application, but assumed to be -40 °C to 121 °C. Exposure to contaminants is covered in Section 4.

3.1.4 Interfaces. The belt/pulley interface is covered by GMW16242 and GMW16290.

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3.1.5 Usage Definition. General purpose.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Reported Data. The following data must be submitted for all belt compounds which are intended to meet this standard. The data is needed only once for initial approval prior to belt sourcing, and not on individual applications.

3.2.1.1.1 Belt Stiffness. The static and dynamic belt stiffness shall be submitted in units of Newton per rib (N/rib) at 20 °C and 60 °C, or over a range of temperature. It shall be measured on a belt strip cycled sinusoidally, or on a two-pulley fixture either rotated or torsionally cycled on both new and conditioned belts (48 h of hot box). Strain must be varied from 0% to 1.0%, since dynamic stiffness is a function of same. If data under these exact conditions is not available, the burden of proof of equivalence is on the supplier. The variation of this value in production over six (6) sigma shall also be reported. This is a cord property and is required to correctly calculate belt tensioner travel and dynamic performance.

3.2.1.1.2 Length Change with Temperature. The variation of belt length as a function of temperature in degrees Celsius (°C) with a load of 45 N/rib from -40 °C to 120 °C shall also be reported upon request. This is a function of both cord material and cord treatment, and is required for correct belt tensioner travel determination.

3.2.1.1.2.1 New Belts in Assembly Plant. The transient length change properties of the unloaded belt after cure and length measurement in the production process and then after shipment to the assembly plants must be reported. The same properties must also be identified in assembly plant storage to assess the impact of events such as a strike or extended shutdown. This is to be reported at 20 °C as a curve with points close together at the rapid transition just after cure/measurement.

3.2.1.1.2.2 Belts on Vehicle in Service. The steady state rate of shrinkage at 100 °C, and loaded with 45 N/rib, with time and temperature in service to be expected throughout the life of the belt must also be reported.

3.2.1.1.2.3 Service Parts Shelf Life. The effect of cord treatment on shelf life as it relates to length shall be reported. The data required is the change in length at 30 °C, with the belt unloaded, over 6 months and 12 months at a relative humidity of 10%. Equivalent data will be considered, but may not be accepted.

3.2.1.1.3 Tan δ . This information is required only in the case of two (2) different belt constructions from the same supplier. With just one construction, the data from the other tests will suffice to evaluate hysteresis sensitivity of the rubber layers of the belt. This value must be reported after testing on coupons cut from calendared material without reinforcement (fiber, fabric or cord) and then again with fiber in the rib stock (as applicable). Material must be preloaded by 3% to 10% of its thickness.

3.2.1.1.3.1 Temperature Frequency Amplitude Notes.

- 20 °C, frequency sweep Hertz (Hz) at a compression of 2% to 3% of its thickness, run to temperature stabilization.
- 100 °C, same.

If an equivalent measurement method can be proven, it may also be used to satisfy this paragraph.

3.2.1.1.4 Belt Efficiency. Belt efficiency (%) shall be reported under the following conditions:

- **Temperature:** 20 °C and 121 °C.
- **Strand Tension:** 2% stretch and 10.4 kW load.
- **Pulley Size:** 60 mm pulley and 180 degree wrap, and 127 mm pulley and 180 degree wrap.

The test rig is conceived as a two-pulley setup with constant load (dead weight) applied opposite the driver. Speed is to be 2 m/s. Other rig options yielding the same results will be considered, but must have Technical Specialist approval. This information shall be used for fuel economy and other performance calculations.

3.2.1.1.5 Belt Tensile Strength This new parameter is important on high tensile loaded drives. The development test is to be run on a tensile test machine with six (6) rib belts over two (2) pulleys. A minimum of six (6) sleeves of belts, made in production with production processes, are to be tested. Every belt is to be broken and the data presented on individual belts and treated statistically for one, two and six (1, 2 and 6) standard deviations to establish process capability. The sleeves are to be built over a period of time and not consecutively. All cord types are to be tested. Consultation with the Technical Specialist is to be done before performing this test. Tensile strength required values and minimum levels will be set based on individual application requirements.

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As with all of the Section 4 validation tests, none are to be performed in production, but rather to establish the belt's performance in general, and not on individual applications.

3.2.1.1.6 Belt Cord Line Deviation This parameter is important for all applications, but especially those which carry high tensile loads.

The belt cord line must be planar within 25% of the diameter of an individual cord as defined as a circle contacting the outer fibers of all of the cord bundles. This is to be established by cutting and measuring the belts used to measure tensile strength in 3.2.1.1.5. As with that data, statistical process capability and individual measurements must be submitted.

3.2.2 Physical Characteristics.

3.2.2.1 Dimensions and Capacity.

3.2.2.1.1 Dimensional Accuracy. Belt profile must meet GMW16290 drawing template requirements. Variables unique to some suppliers include root profile, rib angle, rib flank profile and tip radii profile. The engineering drawing is to use the GMW tolerancing method. Absolute values of the dimensions to the points on the rib flank profile will be determined by establishing the profile requirement with the belt in a flat position. It is required to capture the profile digitally with a digital profilometer or vision system. The dimensions are to be submitted by the supplier for use on the detail drawing.

Note: The new template encompasses profile of a line dimension which requires use of digital profilometers/vision systems or in production to control quality. More specifically, optical comparator information is not acceptable and this equipment is to be eliminated from the production environment for process control.

Note: The profilometer/vision system software will use regression of the points measured on the flank of the ribs to calculate the rib angles, and that this can be used to calculate the points on the flanks of the ribs called out on the template (T minus 0.3 and T minus 1.7 (T – 0.3, T – 1.7)).

Molded belts will require far less measurement frequency as opposed to ground or cut profiles, and data can be gained by outsourcing, while cut or ground constructions require profilometers/vision systems at each manufacturing location.

3.2.2.2 Mass Properties. Not applicable.

3.2.3 Reliability.

3.2.3.1 Reliability Evaluation Point. Evaluated by performance to validation test series and manufacturing process approval.

3.2.3.2 Reliability Requirements. Supplier must meet requirements of Section 4, and have production manufacturing process approved by Global Technical Specialist.

3.2.4 Serviceability. This is a system issue, not covered in this standard.

3.2.5 User System/Subsystem/Component/Part Interface. Not applicable. The interface is not the responsibility of the supplier.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts Selection Guidelines. The belt rubber compound and cord is at the discretion of the supplier to meet the requirements of this specification.

3.3.1.1 Material Guidelines. In general, only Ethylene Propylene Diene Monomer (EPDM) rubber shall form the basis for the rubber compound. Exceptions require Technical Specialist approval. Cord material is either polyamide 4/6 or 6/6 and for some applications, a modified polyester material.

3.3.1.2 Processes Guidelines. Not applicable.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.2 Design Guidelines and Constraints.

3.3.2.1 Design Considerations. In order to establish the required length and load to define the belt which will prevent slip, the following variables must be defined:

- Process capability of the belt manufacturing process to $\pm 4\sigma$.
- Variation of the pulley center locations in the accessory drive due to tolerances, and as a function of temperature using variation simulation analysis.

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- Tensioner arm excursions under all transient conditions, including limp home mode, torque converter protection under brake torque, and Active Fuel Management (AFM).

3.3.3 Identification and Marking. Label requirements shown on engineering chart/drawing.

3.3.4 Workmanship. Not applicable.

3.3.5 Interchangeability. Not applicable.

3.4 Documentation. See individual paragraph requirements.

3.5 Support of System/Subsystem/Component/Part After Sale. Supplier must provide root cause analysis and corrective action to issues identified in service/warranty by Supplier Quality and/or Product Engineering.

3.6 System/Subsystem/Component/Part Operator Training. Not applicable.

3.7 System/Subsystem/Component/Part Characteristics. Not applicable.

3.7.1 System/Subsystem/Component/Part Definition. Not applicable.

4 Validation

4.1 General.

4.1.1 Basic Durability Goals. At the vehicle level, the requirement is for 240 000 km (150 000 mi) and fifteen (15) year life for cars and light duty truck applications at worst case conditions, such as taxi cabs in the desert Southwest, and 330 000 km (200 000 mi) and fifteen (15) year life for heavy duty trucks. The responsibility for meeting these goals is the purview of the cognizant release engineer. It is recognized that the 240 000 km (150 000 mi) requirement assumes a conservatively (meeting the GM internal Bill of Design) designed drive and that the actual performance will degrade if significant variables which affect rubber fatigue exist (higher ambient temperatures and loads, small pulleys on tight side, short spans, etc.) Requirements of the belt supplier as they relate to the vehicle requirements are limited to the bench tests and other requirements in this specification. This test series is to be performed only once for each belt construction as a prerequisite for approval by the Global Technical Specialist. It precedes all engineering and sourcing activity and the approval is required for a supplier to be considered for future GM business. Successful completion covers all future applications. It is not to be performed on individual applications, and has no bearing upon the Production Part Approval Process (PPAP) or production environment, which deal with individual applications/part numbers.

4.1.1.1 Reference Duty Cycle. For the purpose of accomplishing a correlation between the tests herein and actual vehicle operation, Table 1, showing the generic duty cycle is to be used, based on measurement of many actual customer vehicles both in the United States and in Europe.

Table 1: Percentage Time ^{Note 1}

United States (Percent)	Europe (Percent)	Speed (RPM)
20	20	600/idle
20	20	1000
20	15	1500
20	20	2000
18.4	10	2500
1.0	4.9	3000
0.5	10	4000
0.1	0.1	6000/maximum

Note 1: Accessory Loads: Generator = Constant 7 Nm; Air conditioning compressor = 13 Nm; Power steering pump = 2 Nm; Water pump load is a cubic function with speed passing through 7 kW at 6000 rpm.

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