GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW16328

Engine Accessory Drive High Torque and Tension 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 contains all information necessary to design, analyze, develop, validate, and manufacture accessory drive high torque/tension belts.

1.2 Applicability. This standard covers supplier requirements for high torque and tension engine accessory drive belts.

1.3 Remarks. This standard covers only high torque/tension belts. There are two other accessory drive belt specifications that cover normal polyester and aramid cord belts, GMW16242, and low modulus cord belts, GMW16329.

2 References

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

2.1 External Standards/Specifications.

ACEA A3/B3	DIN 70070	SAE J369	SAE J2236
ASME Y 14.5M	ISO 1431-1	SAE J1459	SAE J2432
ASTM D3395	ISO 22241		

2.2 GM Standards/Specifications.

GMW3059	GMW16242	GMW16290	GMW16329
GMW3232			

2.3 Additional References.

Johnson Matthey**,** Incorporated, Taylor, Michigan (www.matthey.com)

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 five basic layers: rib, cord and backing, with an adhesion layer at the cord line on both sides of the cord and 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 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 and Z twist. There is no intent to exclude other approaches to eliminating belt tracking error, but any proposal would need to be approved by the Technical Specialist.

3.1.2.1.2 Backside Material. At this juncture, 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.

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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.

On sensitive applications and on molded belt constructions, a butt splice on all rubber belt layers outside of the cord layer may be a requirement.

Note: Understanding of these requirements 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 less than 0.05 mm maximum, by either printing the label or either pre- or post- curing ink from a very thin transfer film. It is also possible to use a rubber support backing for the label ink that would be compatible with and part of the belt after curing.

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 High Torque. These belts are for high torque applications, such as supercharged engines and Belt Alternator Starter (BAS) applications. As such, they have special rib stock and adhesion layers and cord construction to resist rib separation under torque.

3.1.2.2.2 High Tension. These belts have aramid cord, like many normal belts, covered in GMW16242, and are not to be confused with same.

3.1.2.2.3 Reduced Rib Count. These belts can also be used to reduce rib count where space is limited or to save mass/cost.

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.

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 N/rib at 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 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.

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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 six (6) months and twelve (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 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) at an amplitude 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 (percent) shall be reported under the following conditions:

- **Temperature:** 20 °C and 121 °C
- **Strand Tension:** 100 N/rib, 200 N/rib and 400 N/rib 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 conceptualized 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.

3.2.2 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. In this position, the rib angles and profile shall be 40 degrees as determined by a contact/non-contact digital profilometer or vision system.

Note: The new template encompasses a profile of a line dimension which requires use of digital profilometers or vision measurement systems 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 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).

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 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 the Global Technical Specialist.

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

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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. Belt construction 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.

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 ± 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
- 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 250 000 km (150 000 mi) and 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 15 year life for heavy duty trucks. The responsibility for meeting these goals is the purview of the Release Engineer.

It is recognized that the 250 000 km (150 000 mi) requirement assumes a conservatively (meeting the GM internal Bill of Design/Material) designed drive and that the actual performance will degrade if significant variables which effect 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 section.

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 USA and in Europe.

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Table 1: Percentage Time [Note]

USA	Europe	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: Accessory Loads: Generator = Constant 7 N·m; Air conditioning compressor = 13 N·m; Power steering pump = 2 N·m; Water pump load is a cubic function with speed passing through 7 kW at 6000 rpm.

4.1.2 Fifteen Year Life. This requirement results in an application of base polymers or polymer blends other than chloroprene or polybutadiene. The intent of the specification is to require use of base polymers which have as their inherent characteristics excellent heat, cold and ozone/oxidation resistance (without additives) so that they do not harden or glaze over time. EPDM base polymer belt compounds have been identified by all suppliers as a cost effective solution to these requirements, and only these are approved at this time as potential to meet the requirements of this specification. Should an alternative polymer later be demonstrated as compliant to the test matrix, it may be added.

4.1.3 Durability/Performance Tests. This section covers the durability and performance tests which must be passed prior to consideration of a vendor for the production sourcing process. Approval of a source shall be performed by the General Motors Powertrain (GMPT) Accessory Drive Technical Specialist. Approval for sourcing a supplier to a future program will be based on a good balance of performance across all tests.

All tests are to be run to failure, and acceptance will be based upon best industry performance, and will be judged by the Technical Specialist. A sample size of six (6) or as specified is required to relieve the suppliers from an impractical statistical requirement. At least three (3) belts must be completed on every test for future program sourcing, and the remaining three (3) are run based on the results of the first three (3). The particular sensitivities of that application will be considered, and the supplier list may be narrowed based on superior performance to a subset of the tests that address a particular sensitivity.

For all tests, the failure criterion is one (1) crack, although, depending on the frequency of inspection, more than one (1) may be present at the first discovery. A crack is defined as a type "B", which is approximately half the depth of the ribs, or "C" which is to the cord line per SAE J2432. After the first crack, the tests must be continued to reveal the rate of crack growth with increased cycles/time. Exact number of cracks, hours or cycles must be reported on each test belt, and statistics applied to predict the population via Weibull analysis. Confidence limits will vary with sample size. The minimum sample size is six (6) on all tests except the contamination series, which requires three (3). Since only high temperature polymers are approved, all tests will be run at 121 °C or as specified.

4.1.4 Hot/Cold Cycle Test. This test repeats two (2) tests, one (1) at elevated temperature followed by one (1) at low temperature. One (1) cycle is defined as a hot test followed by a cold test. A half cycle is counted as no cycle. Cycles must be completed. The full test description is in SAE J2432**,** Hot and Cold Cycling Test.

4.1.4.1 Hot Test. This four (4) pulley hot test shall constitute the hot portion of the hot/cold cycle test and can serve as a break-in test. A 6PK1200 belt shall run at a 20 N·m load with 629 N constant belt strand dynamic tension with the four (4) pulley SAE J2432 configuration. Speed shall be 4900 rpm and hot box temperature 121 °C. For additional details see SAE J2432, Hot and Cold Cycling Test and High Temperature, Constant Tension Test. Run for 20 h. Cool to room temperature. **Note:** The two idler pulleys have been reduced to 50 mm outer diameter (OD).

4.1.4.2 Cold Test. This test is the cold part of the hot/cold cycle test. Following the 4.1.4.1 hot box test, the same belt is to be installed in cold box at -40 °C to -43 °C and soaked until belt achieves box temperature, and one (1) additional hour at that temperature. Belt is to be driven with same SAE International (SAE) drive configuration at 1500 rpm for 10 s, 100 rpm at the driver pulley after acceleration from rest in 1 s. Cycle is to be repeated for a

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