



Engine Accessory Drive Generator Decoupling Pulley

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

Note: The word **Decoupler** is used by one supplier of these devices, Litens Automotive, as a trademark and is, therefore, not to be used to describe these devices in general.

1.1 Purpose. This Component Technical Specification (CTS) covers supplier requirements for engine accessory drive generator decoupling pulleys.

1.2 Applicability. This specification contains all information necessary to design, analyze, develop, validate, and manufacture decoupling pulleys.

1.3 Remarks. This specification covers two types of decoupling pulleys: isolated pulleys with a spring separating the pulley and generator shaft and pulleys incorporating just a one-way clutch between the pulley and shaft.

2 References

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

2.1 External Standards/Specifications.

ACEA A3/B3	ASTM D573	ISO 1431-1	ISO 11469
ASTM D412	ASTM D575	ISO 9002	

2.2 GM Standards/Specifications.

GMW2	GMW3286	GMW14671	GMW15725
GMW5	GMW4700	GMW15272	GMW16244
GMW3059	GMW14036	GMW15282	GMW16290
GMW3116			

2.3 Additional References.

Hutchinson Aerospace and Industry, Incorporated, Ithaca, Michigan (www.hutchinsonai.com)

Litens Automotive Group, Woodbridge, Ontario, Canada (www.litens.com)

Statement of Requirements (SOR)

Tucker's Pottery, Richmond Hill, Ontario, Canada (www.tuckerspotttery.com)

3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. There are no unique external features, with the appearance driven by function and the particular supplier design execution.

3.1.2 Content.

3.1.2.1 Physical Content. Generator pulley torsional isolators and one-way clutches represent a family of unique devices to modify the direct connection of the generator shaft from its pulley under certain circumstances. There are three general classifications based on functional features. The intent is to modify the torsional behavior and/or rotational inertia of the generator from its pulley.

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Note: These devices are not functionally interchangeable. For a given application, one may be acceptable and another may not meet functional objectives.

3.1.2.1.1 One-Way Clutch. Operates as a **quasi-rectifier** to reduce torsional vibration of the generator shaft/pulley sinusoidal input wave. It does not achieve this effect fully, since it must overcome its own overrunning torque, as well as the drive torque of the generator, before it releases. With high drive torque on most large generator applications, it is likely that there will be no release of the clutch at all, and therefore, no torsional vibration function. It also functions as an overrunning device during engine decelerations, such as wide open throttle upshifts as well as at starts and/or stops.

3.1.2.1.1.1 Mechanical Design. There are two basic mechanical executions: A roller bearing on a ramp (wedge effect) clutch or a **slinky** closed coil spring (called a wrap spring) which changes its diameter with direction of pulley rotation to lock/unlock. A **sprag** clutch uses a series of rockers around a bearing race which lock via wedging in one direction.

3.1.2.1.2 Isolator. Operates as a spring in series between the generator shaft and pulley. The effect is to add a weak spring to the accessory drive torsional system (all of the rotating pulleys/shafts as masses, and the belt spans as springs). This will reduce the first mode natural frequency of the accessory drive torsional system below idle firing frequency. This device provides a fundamentally different function from the one-way clutch, since it can isolate torsional vibration in both directions. The downside of these devices is that the engine passes through the isolator natural frequency during start up and shutdown, both below idle speed, and the result is a very large torsional motion, which usually results in a momentary loss of belt tension, and belt chirp. This phenomenon must be eliminated by adding a one-way clutch in series with the isolator spring, so that the generator can free wheel during this event. For use on Belt Alternator Starter (BAS) systems, the clutch is not to be used, since torque is applied in both directions.

3.1.2.1.2.1 Mechanical Design. There are two basic mechanical executions: a steel torsion spring(s) or a rubber spring between the generator shaft and pulley. One rubber design consists of a four chambered device with vanes which separate them. Another design is a rubber annulus attached to both sides of a bearing, which, in turn, is attached to the generator shaft and the pulley. For the four chamber device, rubber operates in compression only to provide the function, while the vane pairs are attached alternately to the shaft and pulley to provide the compressive force. The Hutchinson (Aerospace and Industry, Incorporated) device sees alternating stress, so it has a large rubber spring. It has limited tuning authority, and a large space claim. The four chamber device has very limited tuning authority, and is not recommended. The rubber spring devices have sensitivity to durability and start up and shut down chirp, as well as limited tuning authority, so they cannot be considered as an alternative. They are not approved for use by GM.

3.1.2.1.2.1.1 Rubber Material Requirements. For a rubber spring design, there are limitations in material based on the functional requirements. In order for the device to be functional throughout the temperature range of -40 °C to 125 °C, the following spring materials shall not be used:

- Natural rubber or similar elastomers: Polybutadiene Rubber (BR), Styrene-Butadiene Rubber (SBR), Polyisoprene Rubber (IR).
- Chloroprene (CR).
- Chlorosulfonated Polyethylene Monomer (CSM) or Alkylated Chlorosulfonated Polyethylene Monomer (ACSM).
- Nitrile: Butadiene Acrylonitrile Rubber (NBR).
- Acrylics: Polyacrylate Monomer (ACM).

The elastomer of choice must be approved prior to consideration of the design for evaluation or sourcing.

3.1.2.1.3 Combined Isolator and One-Way Clutch. A steel torsion spring, with one end nested on a shaft, drives a one-way clutch attached to the pulley with a ball bearing, or roller bearing and/or bushing to control pulley alignment. This device provides the broadest potential functional performance of the design alternatives.

3.1.2.1.4 BAS Application. Belt Alternator Starter applications are significant departures from normal applications in several respects. If the Motor Generator Unit (MGU) is used to cancel engine firing torque during starts, or if it is used for torque smoothing during transient events, these devices cannot be used. The BAS systems apply torque in both clockwise and counterclockwise directions. The torque levels are significantly higher during the start condition, and the duty cycle is also significantly different. Validation involves different

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conditions, and the stops in the design, used to limit the spring travel in the start mode, must be validated for impact load, wear and temperature degradation.

3.1.2.2 Functional Content. There are several reasons for requiring these devices:

- Aid in accessory drive control of either crankshaft or generator torsional vibration.
- Reduce hub loads on accessory bearings.
- Reduce first mode accessory drive system resonance to a frequency below engine idle speed. This first mode frequency is dominated by the generator, and that is why the isolators are placed inside the generator pulley.
- Contribute to reduced steering shudder, if the pump is belt driven, by reduction in power steering pump pulley torsional vibration excited by the crankshaft.
- Prevent Wide Open Throttle (WOT) upshift belt slip/chirp caused by generator rotor inertia during transmission shifts or when throttle is released just prior to shifts.
- Enable increased generator output by converting the inertia portion of the accessory drive maximum generator torque requirement to current output torque as reflected at the crankshaft.
- Eliminate or attenuate torsional motion in some BAS application during system torsional resonances.

3.1.2.2.1 Decoupling Function. Must operate at full and minimum generator output under resonant torsional conditions of a particular application as tested prior to source selection. Only those sources which can demonstrate functional performance to the satisfaction of the particular application being sourced will be considered for submission of a request for quote. There are several conditions under which the device must be effective.

3.1.2.2.1.1 Idle. The amplitude of generator torsional vibration under full electrical output conditions must be attenuated at idle under all accessory operating conditions. The attenuation must be at least 50% of the input torsional vibration or as specified by the Release Engineer for the particular application based on its particular needs.

3.1.2.2.1.2 Start/Stop. The device must function during normal start/stop operation at full and minimum generator output so as to prevent belt chirp or any discernible noise.

3.1.2.2.1.2.1 BAS Application Starts. For BAS systems, the device must function for 500 000 starts without degradation affecting its durability during the remaining duty cycle points seen in the durability test. Validation will be required on both start and general durability tests on the same parts.

3.1.2.2.1.3 High Speed Overrun. The device, if it has a one-way clutch, shall allow the generator to overrun during a worst case deceleration from maximum speed (rpm) due to transmission shifting as determined by vehicle testing. The acceptance criterion is to prevent audible belt slip under these conditions.

3.1.2.2.1.4 Lugging. On manual transmission applications, the device must provide acceptable attenuation of the torsional input excitation at as well as below idle speed **and** WOT. There are two lugging conditions; one for developed countries, and the other for Eastern Hemisphere and developing Western Hemisphere countries. The latter consists of repeated part throttle lugging.

3.1.2.2.1.4.1 Lugging For Developed Countries. This event is WOT in high gear from the curb idle speed or below, depending on the particular application, to the speed where torsional input from the crankshaft is not unusually high. This is usually about 1200 rpm, but is application dependent. This is an event, and not a condition, since it represents a sweep from at or below idle speed. Stress on the isolator spring will depend upon its internal design. The application is in North America, Europe and Latin America. Durability must be demonstrated for a duration of 200 h.

3.1.2.2.1.4.1.1 Test Description. Generator input vibration is ± 300 rpm at 2000 rpm mean and $20 \text{ Hz} \pm 2 \text{ Hz}$. The air temperature is 90°C and the hub load is 1200 N with a 90% generator load at 13.5 V. The rig is belt driven with one (1) degree misalignment. Radial clearance to be maximum; grease quantity minimum and clutch (if applicable) interference at minimum. **Note:** Alternator output to be shut off for 10 s every 5 minutes to add overrun function.

3.1.2.2.1.4.1.2 Lugging For Far Eastern and Developing Countries. This event is lugging sequentially in every gear from idle or below idle (minimum possible engine speed) speed in city traffic, which is typical of driving in East Asia, and other crowded urban areas in developing countries. The durability schedule is 600 000 half throttle events of 5 s each or 834 h. Individual applications may vary, based on the Statement of Requirements (SOR).

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3.1.2.2.1.5 Engine Calibration Related Conditions. There are some conditions which expose the decoupling devices to torsional excursions much larger than the normal operating envelope. Each application must be measured to assess the amplitudes of these conditions, and then the duty cycle of the condition must also be established to provide information necessary to validation test the device. These conditions include:

- Camel mode: Half of the cylinders are disabled to reduce the heat rejection of the engine when coolant is lost. This mode has been used, but is not used currently.
- Brake torque limiting: Cylinders are cut out during simultaneous brake and WOT application to reduce the engine output torque to a level which protects the torque converter or other driveline components.
- Active Fuel Management: Cylinders are cut out to improve fuel economy during some low torque requirement conditions.
- BAS related boost, regenerative braking, and other events unique to this application.

Note: It is the responsibility of the application release engineer to identify these conditions and to provide a test vehicle with these functionalities present, so that the device supplier is able to make the necessary measurements.

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

3.1.4 Interfaces. The interfaces are the generator shaft and the belt.

3.1.4.1 Generator Shaft. The generator shaft will vary by generator supplier. The supplier of the decoupling device must work directly with the generator supplier to work out the details on the interface dimensions involved, as well as the tightening torque, which is a critical parameter.

3.1.4.2 Belt to Pulley Interface. The interface must meet the requirements of GMW16290 in regards to the shape and dimensioning of the pulley grooves and flanges.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Torque Capacity. Must be capable (as configured for the most severe application) of transmitting a mean of 34.0 N·m of torque as an instantaneous value including alternator inertia or a constant value of 17 N·m ± 20 N·m of a torsional vibration load for the life of the durability requirements. For BAS applications, a peak torque of 60 N·m must be driven during starting of the engine with the MGU, and motoring or regeneration conditions with up to 60 N·m of torque must be accommodated. In addition to the MGU drive torque, there will be up to 35 N·m of rotor inertia from torsional vibration and at transient events. Torsional excitation energy during torsional belt system resonances will be significantly higher also. All of these values are lower for smaller generator applications. There shall be a maximum of 1200 gm·cm (or as specified for a particular device design and application) of overrunning torque on one-way clutch applications. Some designs depend upon overrunning torque for functional performance, and with these, a more stringent overrunning torque specification may be required.

3.2.1.2 Pulley Size. Must be capable of packaging in pulley sizes ranging from 90.00 mm to 50.00 mm effective diameter (effective = Diameter Over Balls (DOB) minus 0.82 mm) up to 70 mm pulley diameter, and DOB minus 0.99 mm for 70 mm and above diameters.

3.2.1.3 Axial Length. The pulley must package in an axial length that is not to exceed 55.00 mm from the back surface of the existing generator pulley. Some applications will have more stringent length limitations. Generally, the rear configuration must shield the generator front bearing from contamination and avoid blocking airflow for cooling performance. BAS applications are exceptions to both length and diameter.

3.2.1.4 Temperature Operating Range. Must be capable of continuous operation from -40 °C to 125 °C. The 125 °C represents the ambient temperature maximum rating of the generator which shall not damage the decoupler/generator or diminish its ability to meet durability test requirements. Reference GMW14036 for related generator assembly requirements.

3.2.1.4.1 Storage Temperatures. It is also required by some of the generator suppliers to withstand a non-operating, storage temperature range of -45 °C to 150 °C for 1000 h without any deleterious effect on its durability or function.

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