

Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 232 – Generating Set Assembly - Coupling Arrangements

INTRODUCTION

This Applications Guidance Note is the second in a series of four AGNs that look at assembling an alternator to a prime mover:

- AGN232 – Generating Set Assembly – Coupling Arrangements
- AGN233 – Generating Set Assembly – Mounting Arrangements
- AGN234 – Generating Set Assembly – Alignment
- AGN235 – Generating Set Assembly – Torsional Vibration Analysis

COUPLING ARRANGEMENTS

The body of the prime mover – often called the engine ‘bell housing’ – and the alternator frame are usually connected together using an adaptor.

The power transmission between prime mover (engine) and alternator is achieved through a coupling. The coupling will be designed to suit the specific prime mover to alternator configuration and must minimize the effects of torsional vibration and ensure compatibility for torque transmission.

The Generating Set manufacturer will determine the set design and decide on the type of mounting arrangement. He will choose to use a single bearing alternator or a two-bearing alternator.

Alternator Designs

Single bearing design

A single bearing alternator has a bearing fitted to the non-drive end of the main rotor and no bearing on the drive end, as shown in Figure 1. A flexible disc coupling is fitted in place of a bearing to the drive end of the alternator's main rotor. The flexible disc coupling will be selected for direct connection to the drive plate of the prime mover – the engine's flywheel. This type of engine-alternator coupling combination is torsionally rigid but still provides axial flexibility.

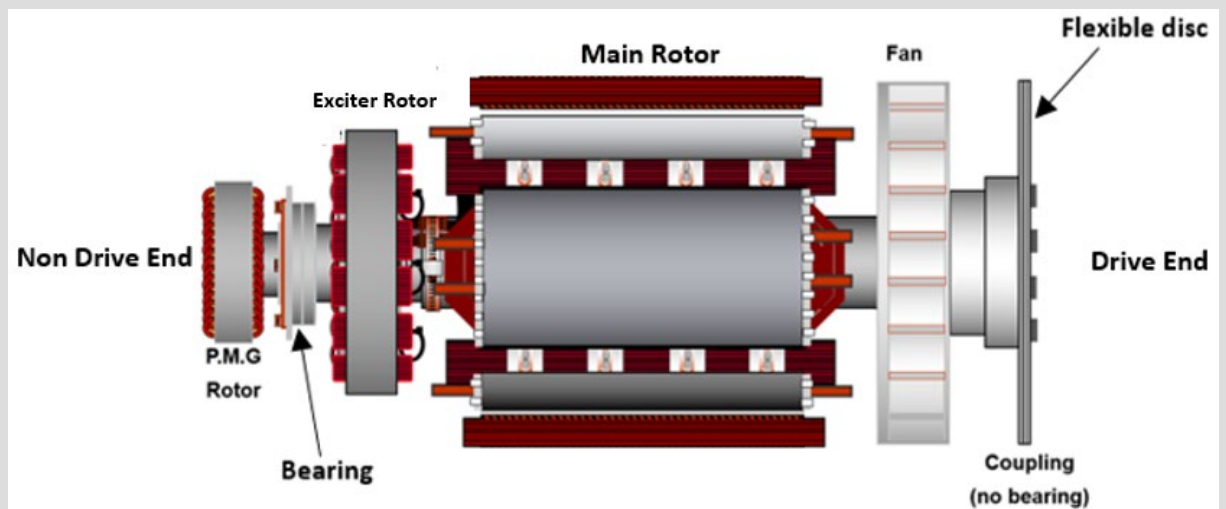


Figure 1: Single bearing alternator

Two-bearing design

A two-bearing alternator provides rotor load support at both the drive end and the non-drive end of the alternator's main rotor, as shown in Figure 2. Two-bearing alternators are often used in applications with higher vibration or transient conditions. The two-bearing design typically allows for rubber coupling drive systems to the prime mover.

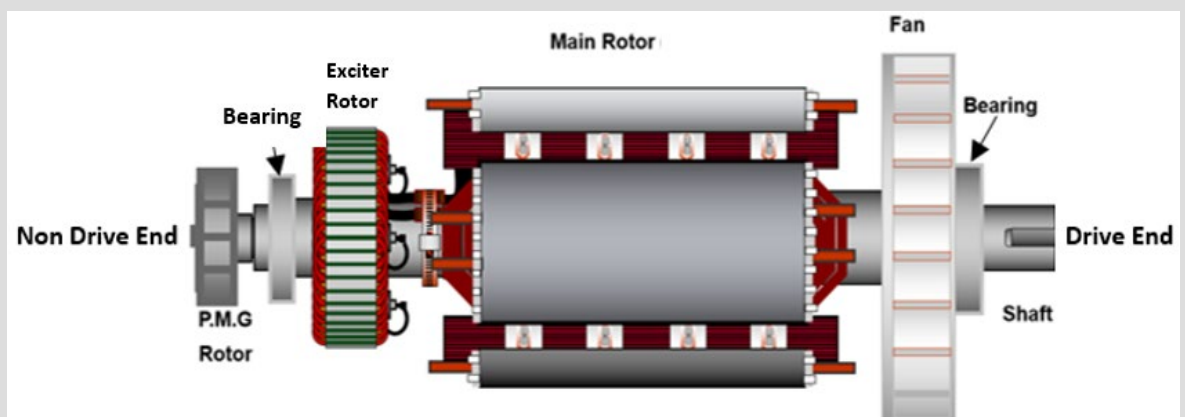


Figure 2: Two-bearing alternator

Coupling Techniques

Coupling techniques include direct drive (close or open coupled), gearbox drive and pulley system. When selecting the type of coupling to use, the system engineer will consider all aspects of the application. The system engineer in consultation with the Generating Set manufacturer will then consider the following design features, as appropriate, of the Generating Set to ensure engine-alternator drive system compatibility:

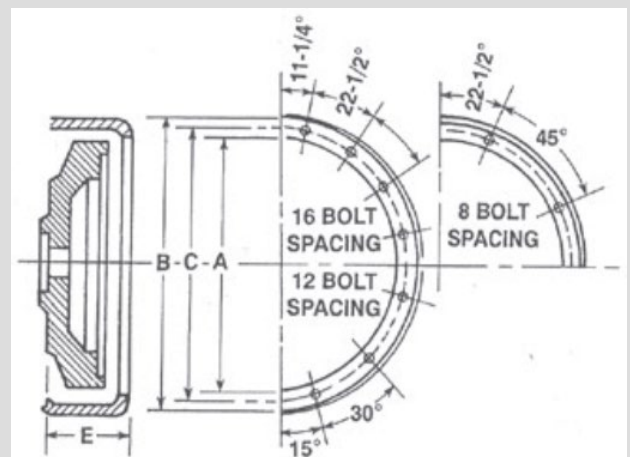
- Suitability of the prime mover to support the alternator's rotor mass.
- Suitable flywheel housing design in terms of stiffness and rigidity with the engine cylinder block.
- Torsional analysis of the Generating Set to ensure engine/alternator compatibility is achieved.
- Suitable Generating Set mechanical support scheme in terms of base-frame design and carefully considered AVM locations.

SAE International Standards

The Society of Automotive Engineers (SAE) standard is used as a guide by the engine manufacturers to define the dimensions of the adaptors and couplings. This method of sizing for adaptors and couplings has been adopted by the Generating Set manufacturing industry.

SAE Standard Flywheel Housing Dimensions (inches)						
S.A.E. No	A	B	C	E	No. Holes	Bolt Size
00	31	34-3/4	33-1/2	3-15/16	16	1/2-13
0	25-1/2	28	26-3/4	3-15/16	16	1/2-13
1/2	23	25-1/2	24-3/8	3-15/16	12	1/2-13
1	20-1/8	21-3/4	20-7/8	3-15/16	12	7/16-14
2	17-5/8	19-1/4	18-3/8	3-15/16	12	3/8-16
3	16-1/8	17-3/4	16-7/8	3-15/16	12	3/8-16
4	14-1/4	15-7/8	15	3-15/16	12	3/8-16
5	12-3/8	14	13-1/8	2-13/16	8	3/8-16
6	10-1/2	12-1/8	7-7/8	2-13/16	8	3/8-16

Housing Dimensions reference (mm)			
S.A.E. No	A	B	C
00	787.4	882.7	850.9
0	647.7	711.2	679.5
1/2	584.2	647.7	619.1
1	511.2	552.5	530.2
2	447.7	489.0	466.7
3	409.6	450.9	428.6
4	362	403.2	381.0
5	314.3	355.6	333.4
6	266.7	308.0	200.0



SAE Standard Industrial Flywheel Dimensions (inches)							
Nominal Clutch Dia.	A	B	C	E	AN (G)	No. Holes	Bolt Size
6-1/2	7-1/4	8-1/2	7-7/8	2-13/16	1-3/16	6	5/16-18
7-1/2	8-1/8	9-1/2	8-3/4	2-13/16	1-3/16	8	5/16-18
8	8-7/8	10-3/8	9-5/8	3-15/16	2-7/16	6	3/8-16
10	10-7/8	12-3/8	11-5/8	3-15/16	2-1/8	8	3/8-16
11-1/2	12-3/8	13-7/8	13-1/8	3-15/16	1-9/16	8	3/8-16
14	16-1/8	18-3/8	17-1/4	3-15/16	1	8	1/2-13
16	18-1/8	20-3/8	19-1/4	3-15/16	5/8	8	1/2-13
18	19-5/8	22-1/2	21-3/8	3-15/16	5/8	6	5/8-11
21	23	26-1/2	25-1/4	3-15/16	0	12	5/8-11
24	25-3/8	28-7/8	27-1/4	3-15/16	0	12	3/4-10
Delco Industrial Flywheels							
15.5D	—	15-1/2	13-7/8	—	23/32	8 (4x2)	5/8-11
17.75D	—	17-3/4	15-1/2	—	23/32	8 (4x2)	5/8-11

Flywheel Dimensions reference (mm)				
Nominal Clutch Dia.	A	B	C	AN (G)
6-1/2	184.2	215.9	200.0	30.2
7-1/2	206.4	241.3	222.3	30.2
8	225.4	263.5	244.5	61.9
10	276.2	314.3	295.3	54.0
11-1/2	314.3	352.4	333.4	39.7
14	409.6	466.7	438.2	25.4
16	460.4	517.5	489.0	15.9
18	498.5	571.5	542.9	15.9
21	584.2	673.1	641.4	0
24	644.5	733.4	692.2	0

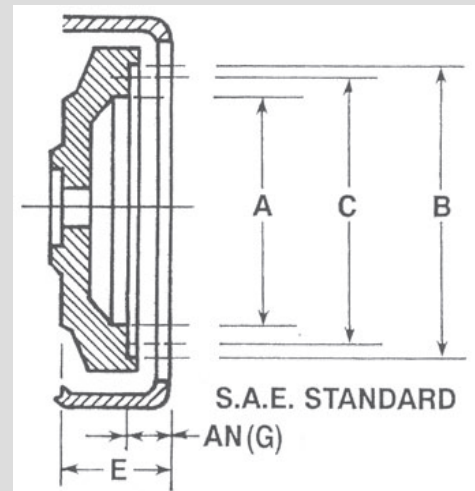


Figure 3: SAE Adaptor and Coupling combinations

SAE designs, as shown in Figure 3, specify the dimensions - diameter, length, width, and tolerance - for engine flywheel housings and the mating transmission housing flanges. Typical adaptor dimensions used on alternators range from SAE 00 to SAE 6 (adaptor sizes) and typical dimensions for the coupling discs used on alternators range from SAE 24 to SAE 6.5.

Adherence to SAE designs ensures consistency in the product and system configuration when interfacing with other standard-compliant equipment. The correct SAE arrangement for a Generating Set is always determined by the prime mover.

Types of alternator-engine integration designs

Single bearing design concept

A single bearing alternator design, as shown in Figure 4, requires an adaptor housing with the correct SAE specification to mate directly with the engine flywheel housing, which will maintain a static alignment. The flexible coupling disc and flywheel SAE combination ensures correct rotating alignment and correct bolting pattern for torque transmission.

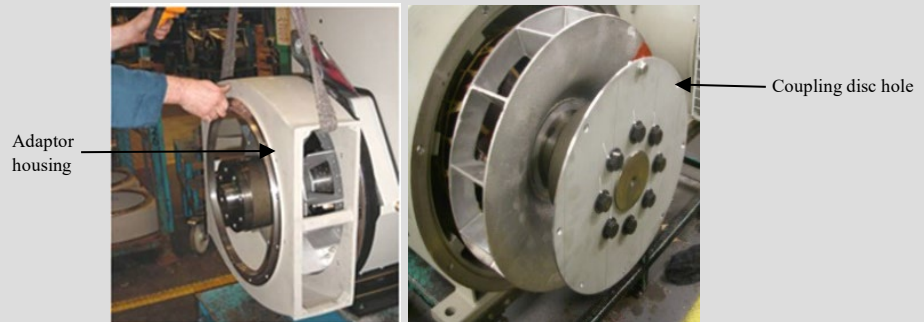


Figure 4: Adaptor (left), and coupling disc (right)

Single bearing alternators are available with a selection of industry standard adaptors (bell housing) and flexible coupling discs to fit most engine types. Figure 5 shows an example of a single bearing alternator, which is close coupled and directly driven by the engine. This connection type is the only option for the single bearing alternator design, due to the use of one bearing to support at the non-drive end.

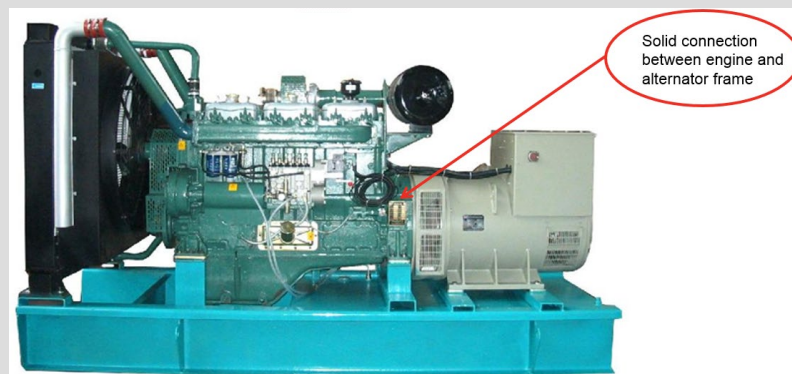


Figure 5: Close coupled single bearing Generating Set

The advantages and disadvantages of using a Generating Set design with a single bearing alternator are detailed in Table 1.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Only one bearing, therefore less maintenance. • Reduces the size and weight of the complete unit and makes the complete unit more rigid, so less substantial base-frame required. • Cheaper compared to two bearing alternators due to the use of one bearing, smaller alternator size and use of standard coupling methods. 	<ul style="list-style-type: none"> • Relies on the prime mover to carry the weight of the alternator shaft in addition to the weight of its own shaft which puts a greater load on the prime mover end bearing. • Requires an inflexible coupling and for very small tolerances of the machined parts. • The flywheel housing must be rigid to withstand the bending moment of the genset.

Table 1: Advantages and disadvantages of a single bearing alternator.

Two-bearing design concept

Two-bearing alternators allow for various ways of connecting the alternator to the prime mover - open or close coupled arrangement. To reduce torsional impact of the rotating system, typically two-bearing alternators are driven by the prime mover through a rubber or elastomer element coupling in between the alternator shaft and engine crankshaft.

An open coupled Generating Set design, as shown in Figure 6, is typically used to reduce the direct transmission of vibration to the alternator bearings. However, alignment of the drive coupling and indirect transmission of vibration, which can be transferred to the alternator bearings through the base frame, needs to be considered during the Generating Set design process.

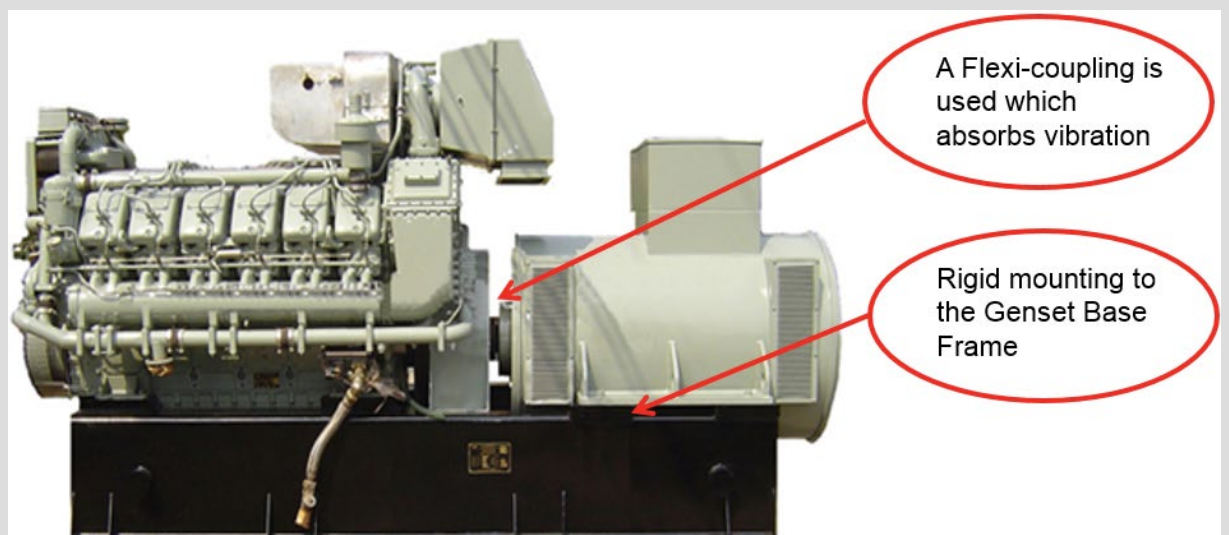


Figure 6: Typical open coupled Generating Set with two-bearing alternator.

A close coupled Generating Set, as shown in Figure 7, utilises an adaptor housing that directly connects the alternator to the engine flywheel housing. Alignment of the coupling and shafting

system is accounted for within the design tolerances of the mating faces and spigot of the connecting housings.

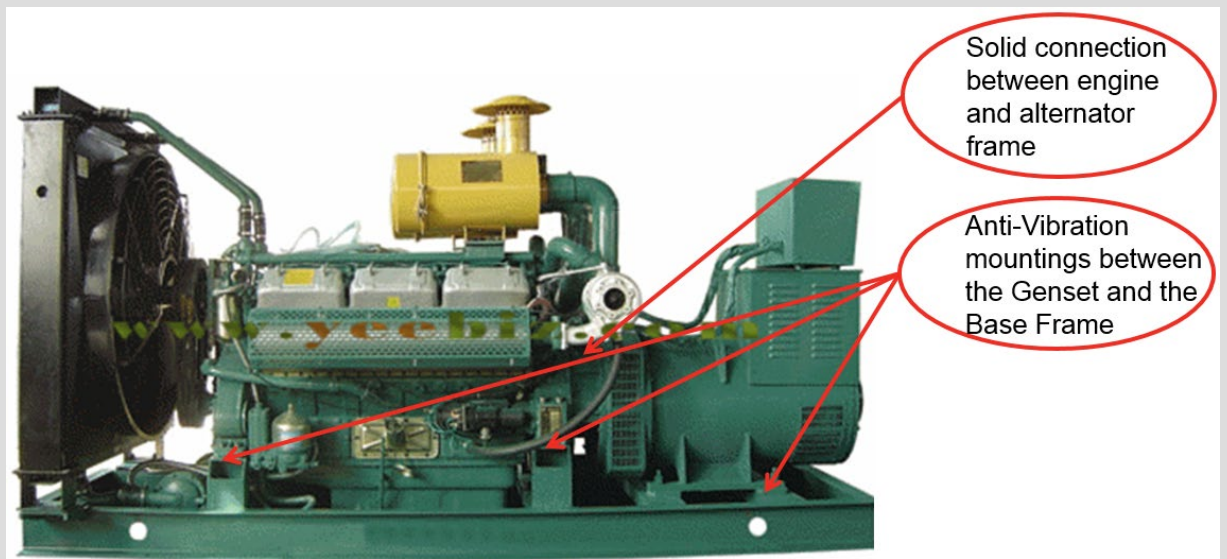


Figure 7: Typical close coupled Generating set with two-bearing alternator.

The advantages and disadvantages of using a Generating Set design with a two-bearing alternator are detailed in Table 2.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Alternator shaft is usually supported by two bearings at the drive end and non-drive end, thereby can be used in situations with higher vibration or lower quality foundations. • Less susceptible to operational vibrations. • Can use both open and close coupling arrangement. • Uses rubber coupling connection to reduce the effects of torsional and transient events. 	<ul style="list-style-type: none"> • More expensive than single bearing alternators due to use of 2 bearings and use of rubber coupling connection (extra cost). • Increased maintenance due to 2 bearings. • Increased weight. • Requires a bedplate with engine/generator mounting pads to ensure a good base for accurate alignment.

Table 2: Advantages and disadvantages of two-bearing alternator

System engineers have access to computer aided design analysis, experimental analysis and torsional vibration analysis. With these aids and knowledge of the application specification, system engineers are able to determine the appropriate Generating Set design for a particular application. Experience has shown that two-bearing alternators are preferred in applications with higher vibration or lower quality foundations. Two-bearing alternators also mitigate against damage during fault conditions or transient events.