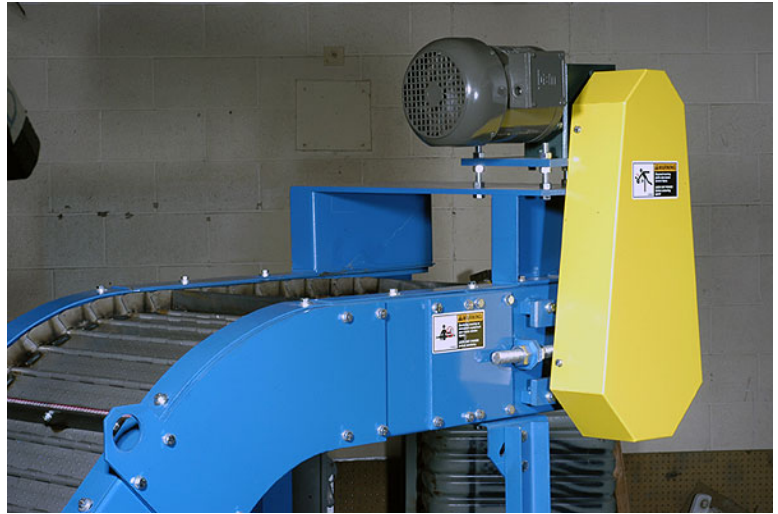


ExpertALERT – Configuring Belt & Gearbox Combinations

Setting up machines with a drive belt or fluid coupling followed by gearbox, or vice versa

The following document describes how to manually configure the MID for a motor / belt / gearbox. This particular machine configuration is not currently handled by the MID Wizard. Please refer to your EAV manual for more information on MID's.

For the example used below, assume a two-location motor (1 and 2, with ball bearings and no free end cooling fan), followed by a drive belt with a 1 to 0.8 speed reduction, followed by a two-location double reduction gearbox (3 and 4, with ball bearings), followed by a large low speed fan with a ball bearing and test location 5. Assume gear tooth counts of 21 and 47 for the first reduction, and 19 and 53 for the second reduction. Finally, assume a nominal (synchronous) motor speed of 1800 RPM with an actual average running speed of 1785 RPM.



Initial MID setup and Component Codes

The MID setup Wizard does not handle machines of this complexity. However, it is easy to use the Wizard to set up an MID for a simple machine, then merely add a component as needed. In this example, use the wizard to set up a motor, gearbox and fan. After completing the initial MID setup, open the MID and add the drive belt. Keep in mind that except for flexible couplings, the MID setup does not care in what order the component codes are placed. Logically (and normally), they are in sequence from driver to driven. However, as long as the pickup codes and fault codes are appropriate, the order is inconsequential. For each coupling, the component code must be listed between the two components physically linked by the coupling, so that the proper shaft rate fault code is addressed. If there is the need (or desire) to insert a component code into an existing MID setup, as opposed to adding one to the end of the sequence, it can be done quickly and easily. Merely click the “add” button and manually enter the applicable component codes, pickup codes and bearings monitored into their shifted locations. In our example, one would add a fourth component, and enter into it the fan information. Then use the back arrow and replace the fan information with gearbox information. Then use the back arrow again and replace the gearbox information with drive belt information. As already noted, however, this procedure is not necessary unless a flexible coupling is involved.

For our example, the following information would be included in the MID setup:

Comp No.	Component	Comp Code	Bearings Monitored	Pickup Codes
1	Motor	15.36	1 and 2	123
2	Gearbox	13.41	3 and 4	2345
3	Fan	6.03	5	54
4	Drive Belt	4.11	none	23

In this case, even though the drive belt is physically located between the motor and gearbox, the above sequence is acceptable.

Reference shaft for Order Normalization:

The speed ratio between the driver (usually a motor) and the gearbox input shaft is not absolutely fixed. Drive belt sheaves tend to wear and slightly shift the speed ratio over time and among units of the same MID. Fluid couplings produce a varying speed ratio due to changes in machine loading. Even when such a machine is tested under very similar load from time to time, the speed ratio probably will vary at least slightly. With order-normalized plots, we want to perfectly line up all of the forcing frequencies possible. By using the gearbox input shaft (1XJ) as the reference shaft for order normalization, all of the various gearbox shaft rates and gear mesh frequencies will line up properly every time. In this case only the 1XM peak and its harmonics may shift a bit.

Fault Codes:

The MID setup Wizard in this case will automatically produce a set of ten fault codes that, given the actual configuration, will certainly be incorrect. The easiest approach to editing them is to collect a set of data for the machine and view the data in graph mode. Change the fault codes while in graph mode.

As noted in the sketch below, use 1XJ as the shaft rotational rate fault code for the gearbox input shaft when the drive belt or fluid coupling is upstream (mechanically) of the gearbox. Similarly, use 1xK as the fault code for the gearbox output shaft when the drive belt or fluid coupling is downstream of the gearbox.

For our example, the following faults codes would be included in the MID setup:

1XJ	=	1.0000	(Gearbox input shaft rate)
1XM	=	1.2500	(Motor shaft rate, equals 1 / 0.8)
1XI	=	0.4468	(Intermediate shaft rate, equals 21 / 47)
1XF	=	0.1602	(Fan shaft rate, equals 21 / 47 x 19 / 53)
G1	=	21.0000	(High speed gear mesh frequency, equals 21xJ)
G2	=	8.4894	(Low speed gear mesh frequency, equals 21 / 47 x 19)

The remaining four fault codes would include, using additional information and discretion after viewing a few sets of test data, possibly BR (belt rate), FB (fan blade frequency = 0.1602 times the number of blades), MB (motor rotor bar pass frequency = 1.25 times the number of rotor bars), or a harmonic of any of the above.

Frequency ranges:

Remember that when you set up a new machine with Wizard and select the appropriate MID, the machine creation Wizard automatically assumes that you want 10 and 100 orders of the nominal speed of the driver component (such as the motor) as specified in the MID setup. For most direct drive (one shaft speed) machines, this pair of frequency ranges is appropriate. In this case, however, many of the forcing frequencies and their lower order harmonics are concentrated in a lower frequency range. If one were to stay with 10 orders of motor in the low frequency range for our example, then many of the spectral peaks of interest would be crowded into the left end of the spectral plot. In general the determination of frequency ranges involves a tradeoff. Each frequency range must be wide enough to include the frequencies of interest, yet narrow enough to provide sufficient spectral peak resolution among various forcing frequencies. Another important general factor is knowing that average baseline spectra are truncated to a defined set of orders of the reference shaft. These truncated values are each one order from 1 to 10, each 10 orders from 10 to 100, and each 100 orders beyond 100. For example, it is not productive to choose frequency ranges such that properly order normalized plots result in 18 and 180 orders of the reference shaft.

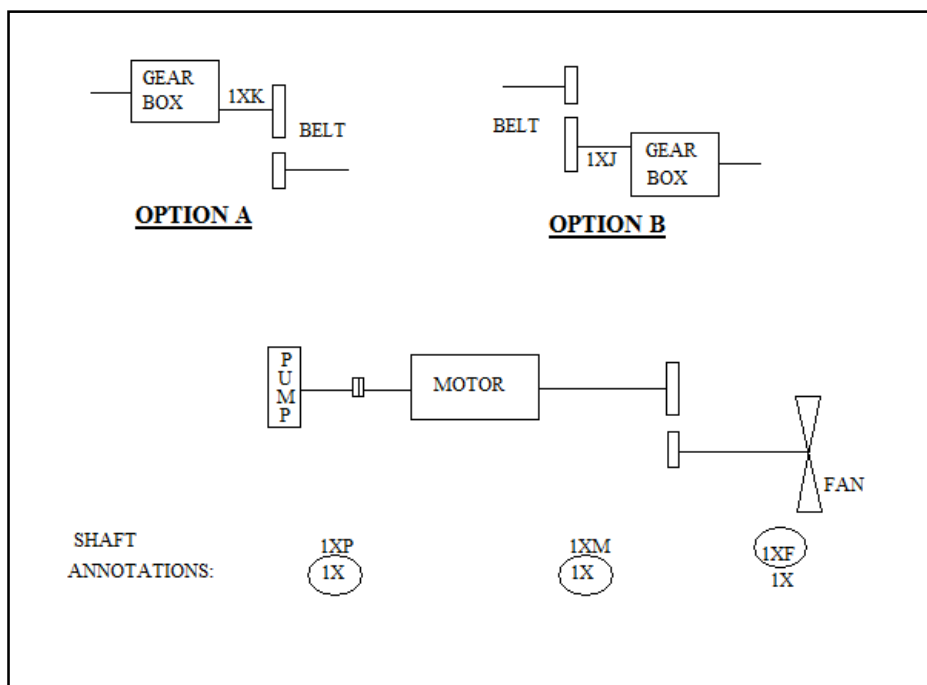
In order example, the maximum motor speed is 1800 RPM. Thus the maximum speed of the gearbox input shaft (1xJ), which is the reference shaft for order normalization, is $0.8 \times 1800 = 1440$ RPM (24 Hz). For the high frequency range, we want to include high speed gear mesh (21xJ) harmonics and motor rotor bar and bearing vibration. Thus we would go with 100 orders of the gearbox input shaft, which is 80 orders of motor ($100 \times J = 80 \times M$). This equates to a frequency range of 2400 Hz. The low frequency range spectra will include many peaks associated with the drive belt, fan shaft, and intermediate shaft, as well as differentiating between 1xJ and 1xM. We would choose 4 orders of the reference shaft (1xJ), which equates to 96 Hz. Round up to 100 Hz. Thus the two frequency ranges would be 100 and 2400 Hz, or 4 and 100 orders of the gearbox input shaft.

Test Conditions:

As with any machine, a successful predictive maintenance program using vibration testing and analysis requires consistent test conditions over time. For machines with fluid or magnetic couplings, machine load has a direct effect on the speed change across the coupling. In order to achieve a fixed pattern of spectral peaks on an order normalized plot, it is necessary to have a fixed speed change. Therefore, as much as possible, such machines should be tested at a fixed load. Then the establishment of average baseline data and practical use of the automated diagnostic system can be achieved. Otherwise, manual review of the data would need to be much more extensive.

General note on shaft annotation fault codes

Once you have defined one or more components of your machine, every shaft in the machine must be identified with an appropriate shaft annotation specified in the fault code definitions for each component. For example, motor shafts must be 1XM or 1X, and pump shafts must be 1XP or 1X. That is why a direct drive motor driven pump can use 1X for the common shaft speed and why a geared or belt driven pump can employ 1xM and 1xP. The system searches the fault codes for the first shaft annotation listed, then the second, and so forth until a match is found. The search is then completed, even if another match would have been made along the sequence. Keep this logic in mind when setting up a complex machine.



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