



WHAT'S REQUIRED TO BRING VIBRATION TESTING IN-HOUSE?

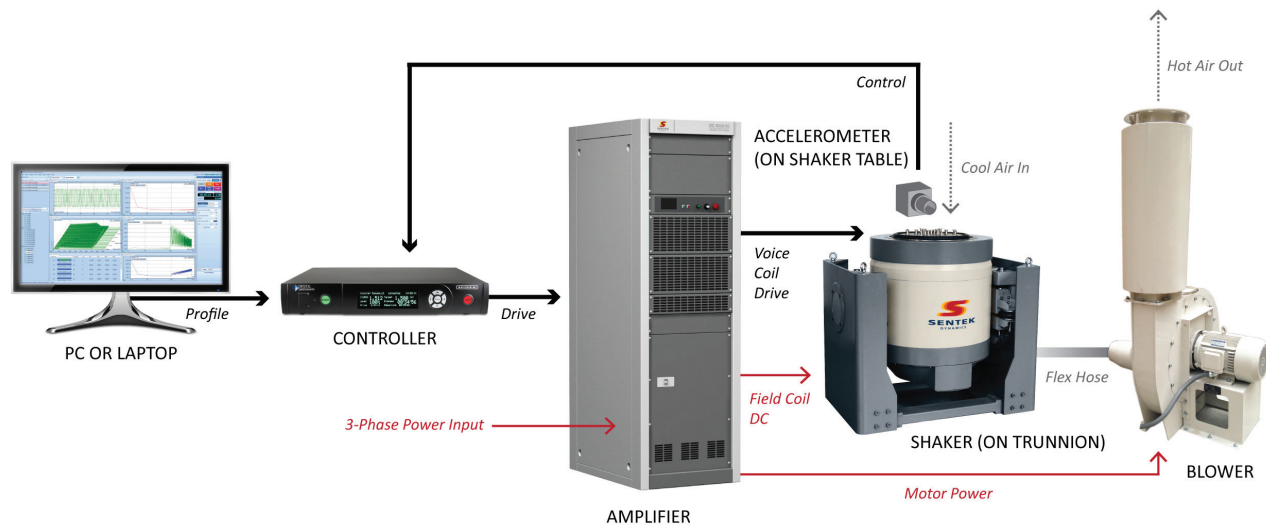


So the question is on the table. Should we use an external laboratory to do our vibration tests, or purchase equipment and do the work in-house? Clearly, using an outside facility avoids the capital costs to build and equip our own testing laboratory. We avoid all of the facility running costs and testing equipment maintenance and we don't need to cultivate our own vibration testing expertise. But, having our own equipment would give us far better control of scheduling, avoid repetitive packing and transport issues and provide us with better security. Further, having such equipment at hand and people who know how to work with it will likely be a huge aide if a new (or revised) product exhibits quality problems detected by vibration testing.

The Elements of a Vibration Testing System

What's involved in setting up a new vibration testing laboratory? First off, you will need to select the right equipment to run the test or tests you are planning to execute. Most people start with a "vertical only" shake capability and select an air-cooled shaker in the low to medium force range. At minimum, your new system will include a vibration

controller, a shaker, an amplifier and a blower. The Controller is the "brain" of the system. It uses an accelerometer on the shaker table (occasionally on the tested specimen) to measure the vibratory motion during a random, swept sine or shock test. The required details of the test are loaded into the controller from a personal computer (PC).



The controller continuously compares the measured *Control* signal to the desired reference *Profile* specified for the test and computes the necessary *Drive* signal for the shaker to force the *Control* to match the *Profile*. The controller also can perform a myriad of analytical support functions including pre-test feasibility analysis and protective limit measurements during the test.

The amplifier is the closed-loop’s “power broker and operational cop”. Its fundamental mission is to amplify the low voltage *Drive* signal from the controller and apply a high-current version of it to the shaker’s voice coil. But, it also provides a strong constant DC current to the shaker’s field coils and 3-phase electrical power to the cooling blower. The amplifier’s control module constantly monitors that all high-power system components are operating safely with all voltages, currents, temperatures, air flow and vibratory stroke within specified allowable values.

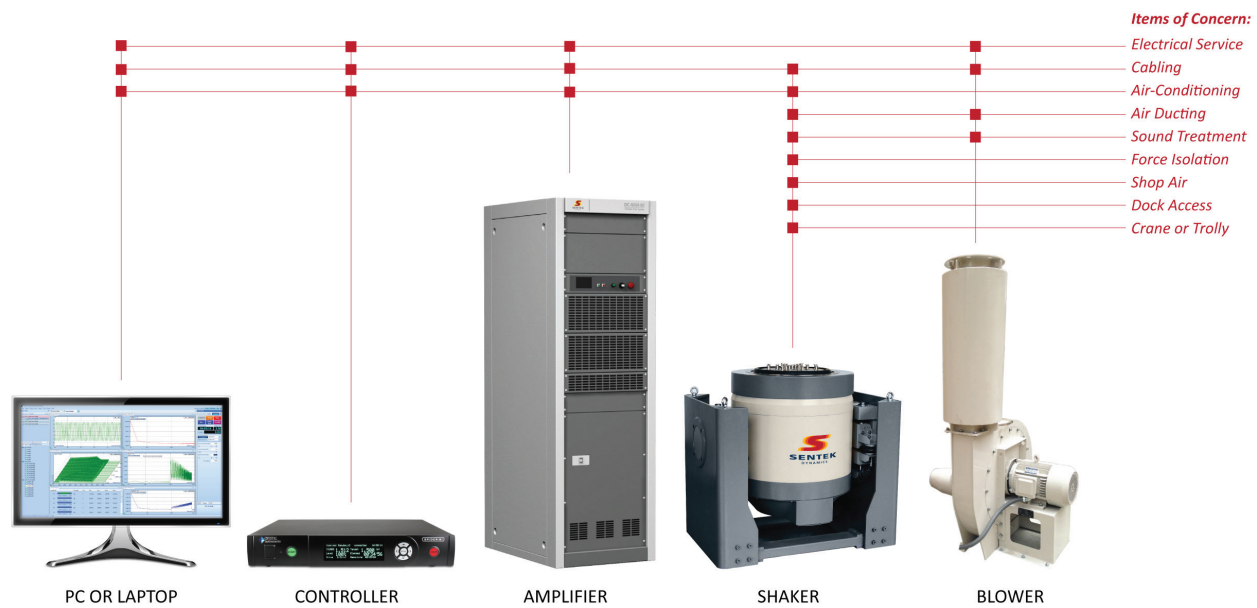
The shaker provides the system’s “brawn”, the electromechanical muscle needed to provide sufficient force to move the device under test (DUT) at the vertical acceleration level required. In order to do this, it must have sufficient force, stroke and acceleration capacity. It must also have a frequency bandwidth that meets or exceeds the test’s specification. Further, it needs the capacity to statically support the device under test and must have a sufficiently large load table to properly attach and support the DUT. In some instances, shaking the DUT horizontally is essential. In this case, the

shaker is rotated to the horizontal and used to drive a *slip table* through a *driver bar*. The slip table and shaker may be purchased as separate free-standing components, or in a common *mono-base* design for easier conversion from horizontal to vertical operation.

The blower cools the shaker. It draws cool laboratory air in through a shroud surrounding the load table. The air flows down over the voice coil and the field coils, past the iron magnetic pole pieces and into an air chamber that is evacuated by a flexible hose leading to the blower. The heated air exits the blower through a silencer. For small systems, the blower may be located in the shaker space. To avoid recirculating the hot air, the blower’s outlet may be vented to the outdoors. For large systems, the blower itself is located outside reducing both noise and recirculated heat.

Planning the Laboratory Space

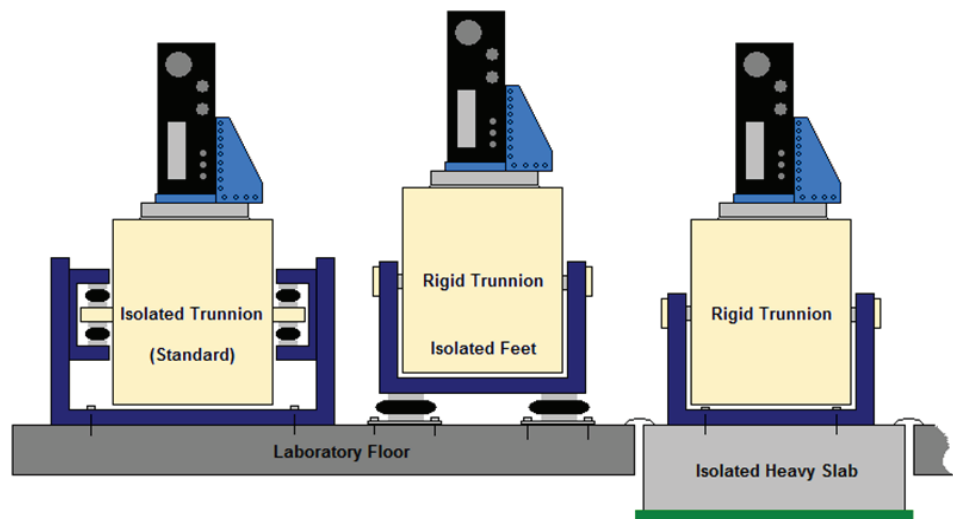
There are a lot of things to be considered in planning a new vibration laboratory beyond what equipment to buy. The dots in the figure below denote 21 “what and where” considerations that you don’t want to overlook. Clearly you need to know the size and weight of everything your lab will house as a start point. You need enough floor space to house everything comfortably, allowing equipment to be used and serviced efficiently. You should plan for at least one meter (3 feet) clearance between the shaker, amplifier, blower and walls, benches or other obstructions. The floor needs to be level and strong enough to tolerate any equipment you need

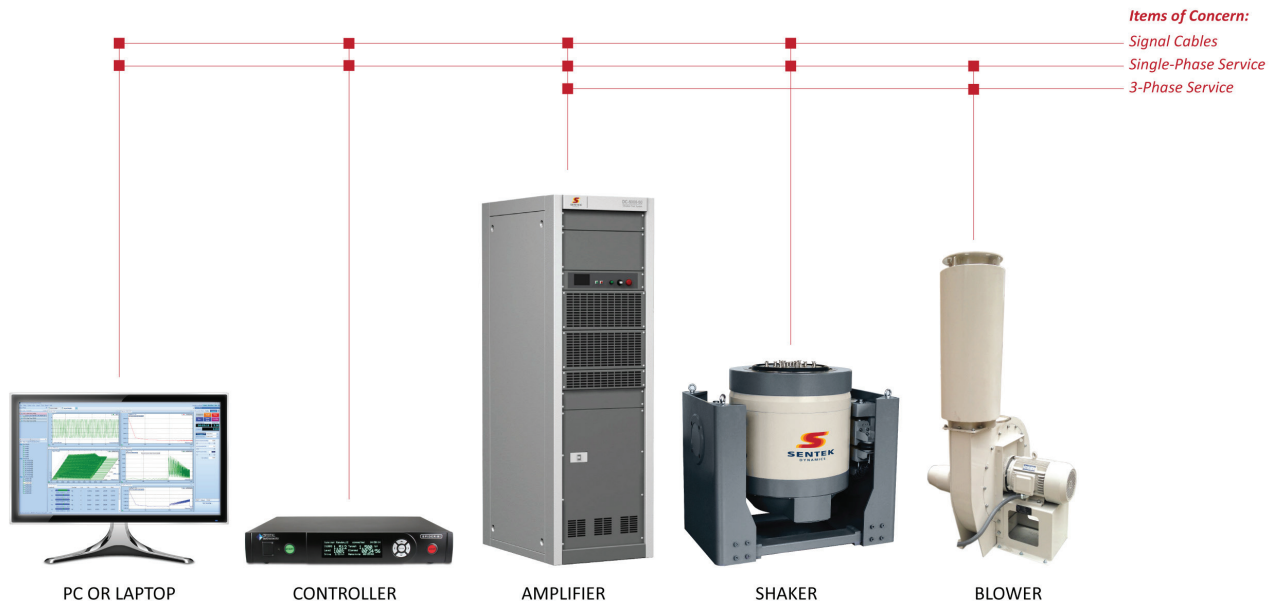


to use to move the test equipment initially and test items thereafter. You'll also need cabinet space to store fixtures and tools and supplies of all sorts.

You need enough ceiling height to get large items in and out. If you are going to test large items, you will need an overhead crane near the shaker and possibly trolley access. You're going to need 3-phase electrical power for the amplifier and single-phase outlets for work lights and power tools near all elements of the system. There will be a lot of wiring and you need to plan for its orderly arrangement preferably in protective wiring troughs allowing maintenance access. You will need clean shop air (ISO 8573-1: class 1.7.1, 0.01 micron particle size, 0.01 ppm oil content) at the shaker. There will be a flexible duct (a.k.a. hose) between the shaker and blower. The hose needs to be safely routed to the blower with a minimum number of right-angle bends. The blower (or at least its discharge) should be outside of the work area. You will need air-conditioning – your shaker system will impose an added heat load on the workspace.

Your lab floor will need to be strong and level – it will be supporting a lot of heavy items. Unfortunately, that strong floor can make your activities very unpopular with other inhabitants of the building. It can transmit the reaction forces of the shaker throughout the building, causing noise and even resonant vibration. Unless properly dealt with, this can be a real source of annoyance. The ideal answer is to situate your shaker on a separate floor slab, isolated from the remainder of the building. When this is not possible, our standard isolated trunnion or air-spring isolators under the feet of your machine can help enormously.





Wiring Considerations – Power, Grounding and Signal Routing

Wiring is always an issue that deserves careful planning. You should plan separate conduits or troughs for signal cables to minimize electrical noise injection. You will need both three-phase and single-phase electrical service. It is likely that these will be separate. In the United States, the most common industrial three-phase supply (277/480 VAC 4-wire wye) provides a line-to-line voltage of 480 VAC; this is what you want to power your shaker amplifier and blower. However, many industrial buildings then use the resulting 277 VAC line-to-neutral voltage for lighting circuits. That may be fine for your overhead lighting, but you are going to need 120 VAC single-phase outlets for the controller, other test instruments, trouble lights and power tools. You can only get that from a 120/240 VAC split-phase, a 120/208 VAC 4-wire “wye” three-phase drop or a purchased 277/480-to-120 VAC transformer.

It is extremely important to provide proper grounding of the system, both for operational safety and to preclude line-frequency ground loop signal problems. The main ground lead should be applied to the amplifier and the shaker and controller should derive their ground connections from this point, using no smaller than 12 AWG copper wire. Signal cables deserve special attention. In order to

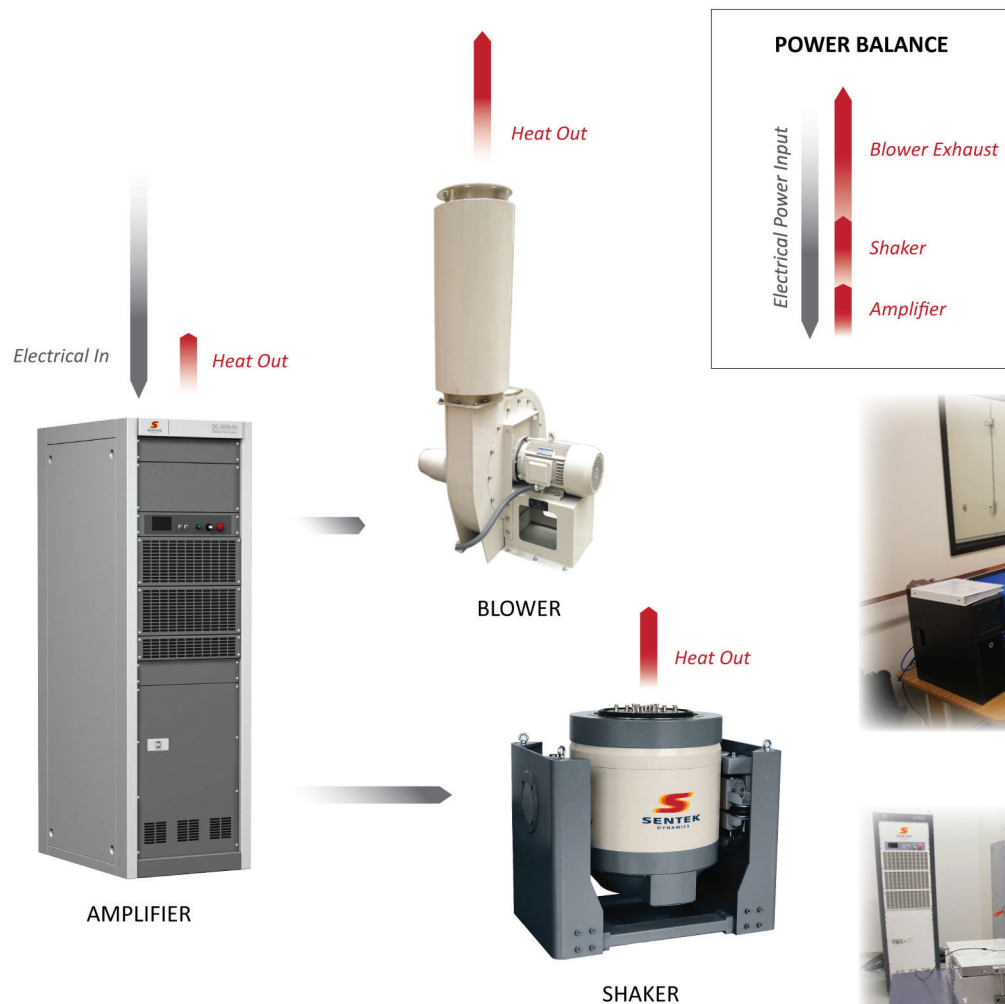
minimize noise injection and ground-loop problems, analog signal leads should be kept to minimum length. Note that the controller accepts the Control acceleration signal from the shaker and may also need to accept other measured accelerations (Monitor and Limit signals) from the shaker-mounted DUT. Hence, the controller wants to be near the shaker. The controller Drive output connects to the amplifier which connects to the shaker. Clearly, the shaker, amplifier and controller need to be close to one another. This does not imply, however, that the PC and the system operator need to be near the shaker.

It pays big productivity benefits to provide a comfortable environment for the staff that runs your vibration tests. This implies placing the PC in a clean, sound-treated and air-conditioned space adjacent to the shaker installation. The recommended Crystal Instruments controllers all use Ethernet® as the interface between the PC and the controller. Ethernet allows long separation distances between the PC and the controller with no loss of communication speed or system reliability. Of very special importance is the fact that *Ethernet uses no ground-referenced signals*. Because all of its digital signals are differential, an Ethernet connection cannot cause a highly problematic ground loop between the remote PC and the control system (as USB and older PC interfaces could).

Blower located outside

Special Considerations for the Control Room

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Control Room



Vibe Laboratory

Dealing with Heat

Heat is always an issue with an electrodynamic shaker installation as a significant amount of electrical power is consumed in operation and converted to heat. It is essential to review the heat load survey for the proposed space; additional air-conditioning capacity is likely to be needed. This should be brought on-line before the laboratory is commissioned. All Sentek Dynamics **PA** Series amplifiers are highly efficient class-D switching amplifiers. They have a thermal efficiency of 90%. Cooling efficiency is harder to characterize and varies significantly between systems. The “big picture” issues are that the total heat generated by the system (the system’s heat output) is equal to the electrical power input to the amplifier. For the shaker at “full song”, the worst case heat load (in BTU/hr) is equal to 3412 times the

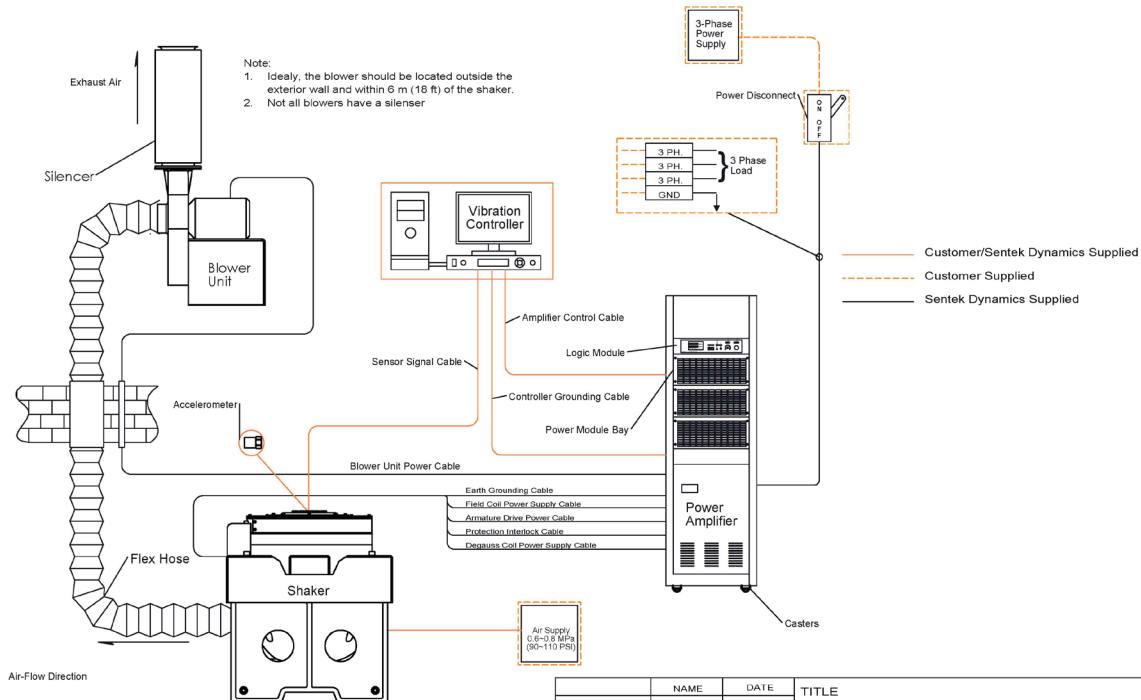
amplifier’s kVA rating. System heat is given off by the amplifier, the shaker and the blower as well as the blower exhaust. Venting the blower’s exhaust to the outside dispels better than 50% of this heat. Placing the blower outside further reduces the laboratory heat load and the noise level.


We’re Here to Help

Creating a vibration test laboratory is a big job. But, as with any engineering project, breaking it down into a series of tasks to be accomplished makes the effort manageable. The Application Engineering staff of Sentek Dynamics is experienced in creating and debugging new installations. They are available to help you during the planning, construction, commissioning and daily use of your new facility.

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REVISIONS					
REV.	ECN	DESCRIPTION	DATE	CHECKED	APPROVED
000		INITIAL RELEASE	05/14/2014	JR	JR
001		New Title Block and Separate Sheets	06/18/2014	JR	JR



	NAME	DATE	TITLE Typical Setup For Air-Cooled Vertical Only Systems			
DRAWN	DL	05/13/2014				
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Total Power Requirement

System Model	380 VAC 3-Phase	480 VAC 3-Phase
L0111A	4.5 KVA; 6.8 A; 9 A Min Slow-Blow Fuse/Circuit Breaker	4.5 KVA; 4.8 A; 7 A Min Slow-Blow Fuse/Circuit Breaker
L0211A	5 KVA; 7.6 A; 12 A Min Slow-Blow Fuse/Circuit Breaker	5 KVA; 6 A; 9 A Min Slow-Blow Fuse/Circuit Breaker
L0315M	5 KVA; 7.6 A; 12 A Min Slow-Blow Fuse/Circuit Breaker	5 KVA; 6 A; 9 A Min Slow-Blow Fuse/Circuit Breaker
L0620M	12 KVA; 18.2 A; 30 A Min Slow-Blow Fuse/Circuit Breaker	12 KVA; 14.5 A; 22 A Min Slow-Blow Fuse/Circuit Breaker
L1024M	20 KVA; 30.4 A; 45 A Min Slow-Blow Fuse/Circuit Breaker	20 KVA; 24 A; 36 A Min Slow-Blow Fuse/Circuit Breaker
M1528A	28 KVA; 42.5 A; 65 A Min Slow-Blow Fuse/Circuit Breaker	28 KVA; 34 A; 51 A Min Slow-Blow Fuse/Circuit Breaker
M2232A	33 KVA; 50 A; 75 A Min Slow-Blow Fuse/Circuit Breaker	33 KVA; 40 A; 60 A Min Slow-Blow Fuse/Circuit Breaker
M3240A	42 KVA; 63.8 A; 95 A Min Slow-Blow Fuse/Circuit Breaker	42 KVA; 50 A; 75 A Min Slow-Blow Fuse/Circuit Breaker
M4040A	42 KVA; 63.8 A; 95 A Min Slow-Blow Fuse/Circuit Breaker	42 KVA; 50 A; 75 A Min Slow-Blow Fuse/Circuit Breaker
M5044A	75 KVA; 114 A; 170 A Min Slow-Blow Fuse/Circuit Breaker	75 KVA; 90 A; 135 A Min Slow-Blow Fuse/Circuit Breaker
M6044A	85 KVA; 129 A; 190 A Min Slow-Blow Fuse/Circuit Breaker	85 KVA; 102 A; 153 A Min Slow-Blow Fuse/Circuit Breaker

Blower Unit

Model	Inlet Flange Diameter	Shaker Model
BU-1	122 mm (4.8 in)	L0111A, L0211A, L0315M
BU-2	123 mm (4.8 in)	L0620M, L1024M
BU-3	200 mm (7.9 in)	M1528A, M2232A, M3240A, M4040A
BU-4	250 mm (9.8 in)	M5044A
BU-5	250 mm (9.8 in)	M6044A

	NAME	DATE
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COMMENTS:



TITLE

Typical Setup For Air-Cooled Vertical Only Systems

SIZE	CAGE CODE	DWG. NO.	REV.
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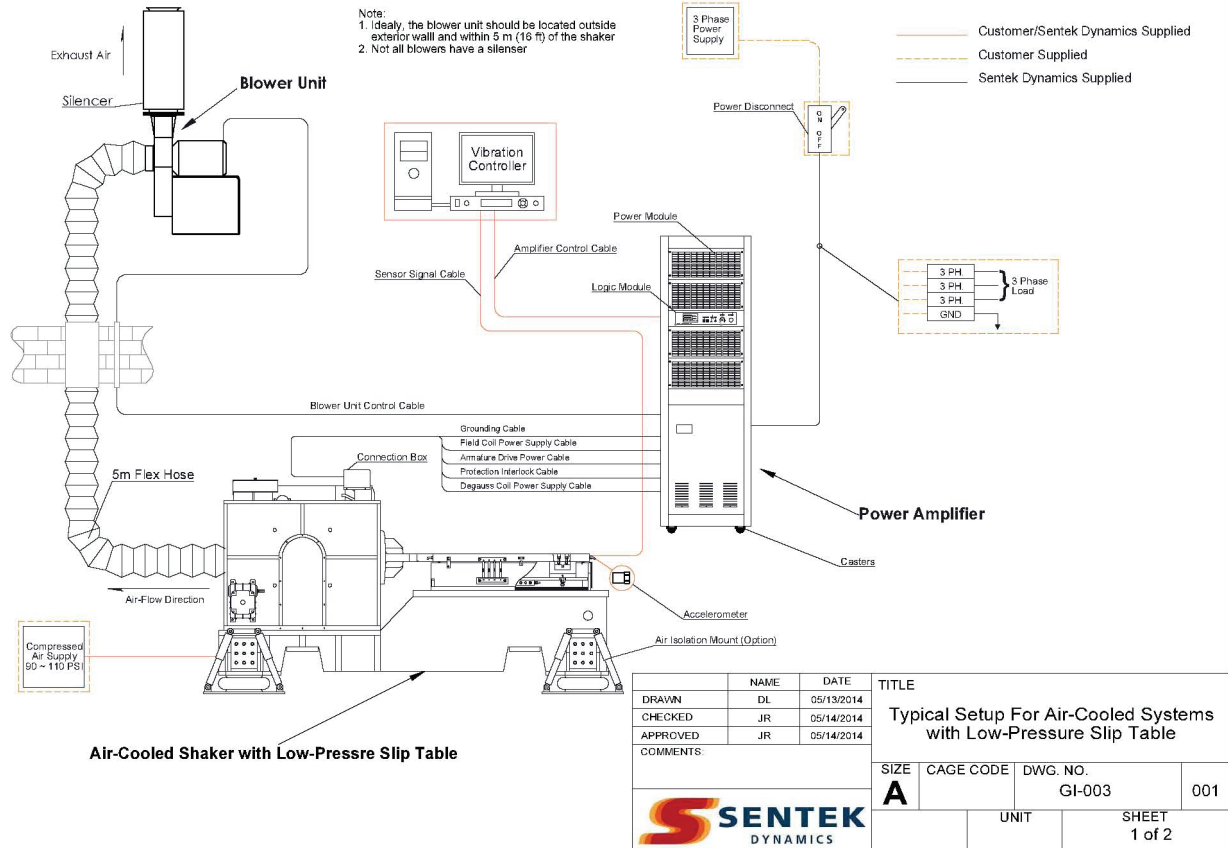
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BU-4	250 mm (9.8 in)	M5044A
BU-5	250 mm (9.8 in)	M6044A

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**TITLE**

**Typical Setup For Air-Cooled Systems
with Low-Pressure Slip Table**

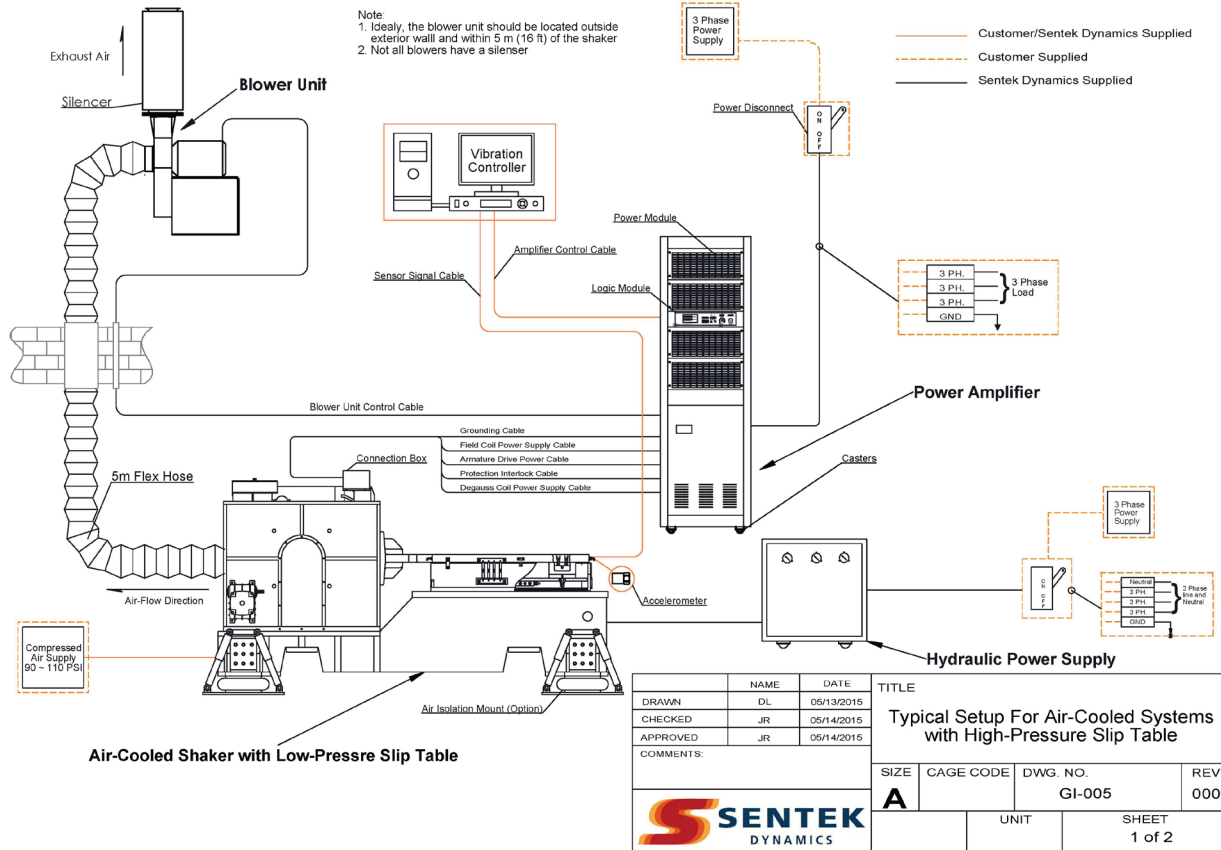
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