The 10 Commandments of Automation Machine Engineering

At PrimeTest Automation, we have more than 15 years of experience developing industrial automation solutions for a wide variety of clients. During that time, we've seen a vast range of scenarios in a variety of industries and have developed a broad spectrum of solutions to address our client's unique challenges. Perhaps the most important thing we've learned during this time is when it comes to machine automation, there are no hard and fast rules. Instead, there are guidelines and best practices that should be followed.

With this in mind, we've developed and adopted what we call "The 10 Commandments for Automation Machine Engineering" — a comprehensive list of do's and don'ts. This whitepaper discusses the details of the 10 commandments we use here at PrimeTest Automation to ensure we continuously deliver automation solutions that meet the aggressive requirements and goals set forth by our customers.

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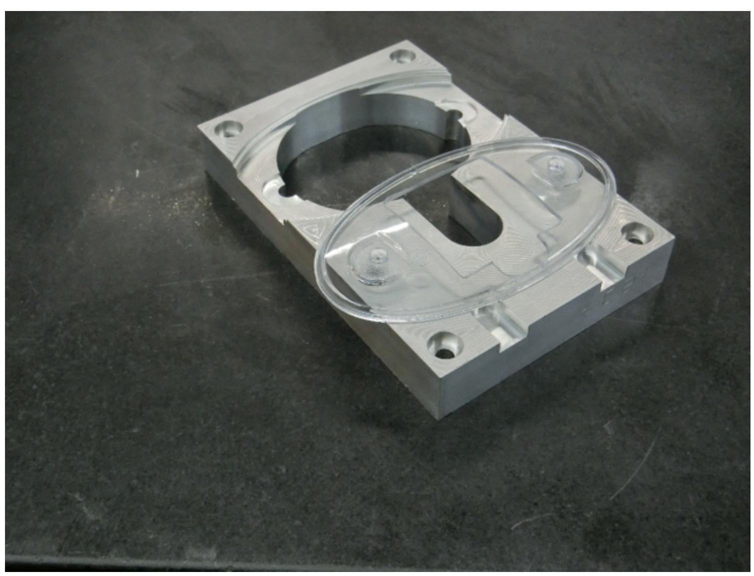
Commandment 1:
Do Not Rely on Gravity

> **If gravity alone is relied on to let the part fall into position, the potential exists for a misplaced part and the results could be disastrous.**

For manufacturing applications, products are typically assembled inside of fixtures that are used to transport products through the various processes necessary to build them. Oftentimes, robots are used to pick-up a part from one fixture, align it with another fixture, and then release the part into the fixture pocket. If gravity alone is relied on to let the part fall into position, the potential exists for a misplaced part and the results could be disastrous.

For example, if parts are being moved to a filling station where a liquid or gel is added into a container and the part is not properly placed in the fixture, your machine could accidentally be covered with that liquid or gel. This error, which is fairly easy to prevent, could greatly hinder your productivity and be costly to repair.

To avoid these situations, parts should always be guided all the way to the bottom of a fixture by the robot before being released. In short, you can never assume a part guided by gravity will land where you intended it to go.

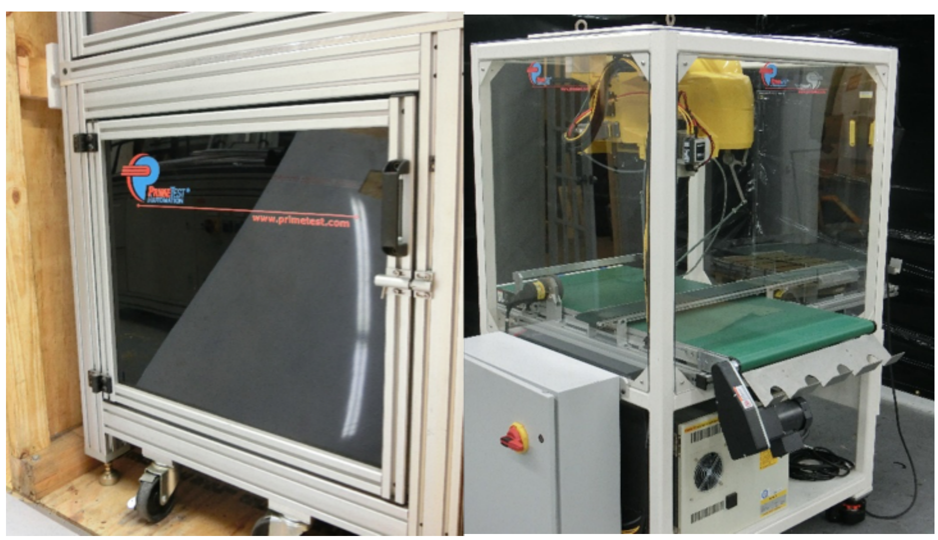


An example of a part that was properly guided and placed into a fixture

Commandment 2:
Start With a Solid Foundation

Every machine sits on a machine base. However, not all machine designers give the design of the machine base proper consideration. Often, large machines are placed on machine bases manufactured from aluminum extrusion that are bolted together with fasteners or T-slot connectors. Because these materials are fairly light and not permanently secured together, those bases are prone to shifting under high inertia loads, such as those generated by a rapidly moving robot, or by the bumps endured during the transportation of the equipment from the machine builder to the end user. This can be a big problem, because when the base shifts, the entire system can become misaligned.

To avoid these issues, we build all of our machines on steel bases that are welded together. We follow the guideline that a stable foundation allows for a stable robot, which increases the accuracy and repeatability of the machine. Additionally, systems using a steel base will not endure shifting during transport, which means less time is needed to reteach and configure the robot once the system arrives onsite.



A comparison of a machine built using an aluminum frame (left) versus a machine using a steel base (right)

Commandment 3: Always Verify Part Presence

You can assume a part will still be where it is supposed to be in the middle of an assembly automation process. A lot can happen that can cause a process to be interrupted or a part to become missing.

Since we are talking about automated equipment, it is easy to assume that once a part is loaded into a machine, it will automatically moves through the process as intended. But in reality, it is a bad idea to rely on the assumption that the part is still located where it should be in the middle of the assembly automation process. A lot can happen that can cause a process to be interrupted or a part to become missing in the system.

For example, a machine could have been accidently shut off, causing a part to be left in the machine at some point, or an operator could have manually removed a part during a repair and not replaced it. Instead of just assuming parts are in place, you should always verify that the part is where it needs to be. We do this by incorporating nest sensors at each point where a new procedure is performed to ensure the fixture is properly loaded.

As we discussed in Commandment 1, the costs associated with assuming a part is in place can be high, both in terms of downtime and dollars spent to make necessary repairs. Thus, there can be a significant return on investment if the appropriate sensors are added to your system from the very beginning. In general, don’t assume anything—verify everything.

A through-beam sensor, shown here, is the most reliable method for indicating a part is present.

Commandment 4:
Do Use a Through-Beam Sensor Whenever Possible

Building off of Commandment 3, there are many points during the manufacturing process where you need to be sure a part is in the right place before an operation is performed. A variety of sensors are available for part detection, including proximity and photoelectric sensors.

Let's look more closely at these options. First, a proximity sensor uses an electromagnetic field to detect the presence of an object without contact. Since these sensors have a limited range for part detection, they aren't always the best option to use when parts have the ability to move around on the manufacturing line. On the other hand, photoelectric sensors detect parts using a light transmitter and a photoelectric receiver.

There are two types of photoelectric sensors available—retroreflective and through-beam. A retroreflective sensor contains both the emitter and receiver in one housing. The light beam from the emitter is bounced off a target and then reflected light is detected by the receiver. Because this method is dependent on how the light is reflected off objects, any differences in surface finish that can change reflectivity can cause the sensor to not detect the light properly.

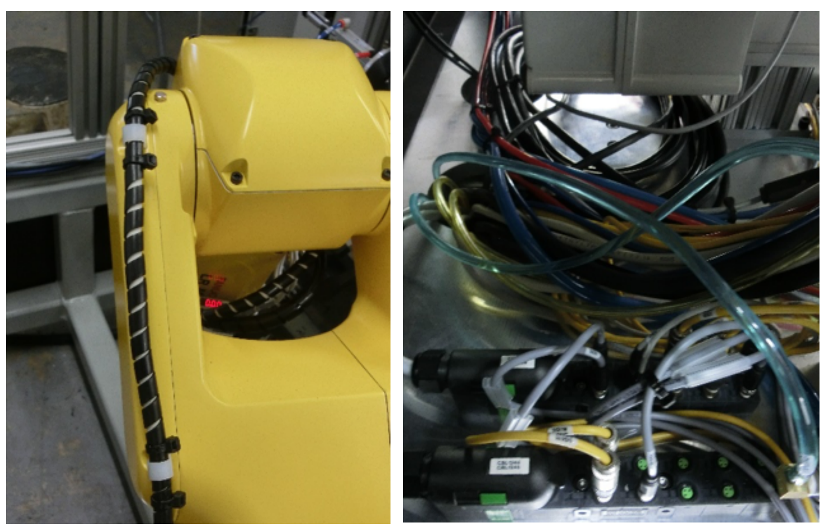
This is a good method, but, in our opinion, the most reliable method to use is a through-beam sensor. This type of sensor is basically setup as a pitcher and a catcher. A light beam is emitted from one side of the sensor and "caught" by a receiver on the other side. As soon as this light beam is broken, you know the object is in place. This sensor is the most reliable method for indicating that a part is present, which is key to the success of the machine.

Commandment 5:
Cable Management Should Not Be an Afterthought

To avoid downtime, repetitive repairs, and increased operational costs, machine designers must think about how the cables will run through the machine and be protected from chaffing, pinching, and stress.

Machines on the manufacturing floor are complex and rely on a variety of cables and hoses to conduct data transfer and communications, provide power, and perform functions such as delivering compressed air. Thus, cable and hose management is critical to the performance of the equipment. However, this component is often overlooked during the design phase and tends to be treated as an afterthought during assembly automation.

To avoid downtime, repetitive repairs, and increased operational costs, machine designers must think about how the cables will run through the machine and be protected from chaffing, pinching, and stress. Methods for accomplishing this protection include determining anchor points and incorporating cable carriers into your design right from the beginning. In short, design cables into the machine, don't make them an afterthought.



The machine on the left takes advantage of cable management best practices by using cable carriers to properly protect the cabling, while the example on the right shows many exposed cables and wires that are likely to get damaged over time.

Commandment 6:
Nothing Gets Fixed in the Truck

Before sending any machine out our door, we believe it is critical to bring clients into our facility to perform a thorough run-through to validate the machine's functionality with our engineering team. At the beginning of the development process, we request our customers establish a set of run-off requirements. This helps us know what is most important to our clients as we design, build, and test their equipment. In addition to looking at their pre-identified key performance characteristics during this time, we encourage clients to be extremely critical and log any additional issues they see, no matter how small they think the issue may be.

We also have our engineers present for the run-off since they are intimately familiar with the machines we develop. We have our engineers observe and catch any issues the customer may not notice. We require this level of depth because we know that once a system leaves our facility, it is the system the customer will receive and use in their facility. Therefore, we want to ensure that even the smallest potential issues are addressed before we send anything out the door. As a rule of thumb, once the machine is packed and placed in the truck, it is no longer accessible for modifications, so the final run-through is our last opportunity to ensure the quality of the system we ship.

During final run-off testing, we pay close attention to all of the details of the system before it leaves our facility.

Commandment 7:
Once You Orient a Part, Don't Let it Go

If you need to reorient a part for the next process step, that means you are spending more time and money.

In most cases, when building a piece of automated equipment, the most expensive part of the system is the equipment used to feed and orient the raw materials going into the machine. These processes are typically done with costly vibratory or centrifugal feed systems or with vision guided robotic systems picking parts at random from bins or off conveyors belts. Thus, once a part is placed in your machine and correctly oriented, you don't want to lose that orientation.

If you need to reorient a part for the next process step, that means you are spending more time and money. When designing a system, consideration must be given to maintaining control of the part throughout the process to avoid having to feed and locate a part twice in any given piece of equipment. The bottom line is, once a part is properly placed into your machine, don't let it go.

Designers should limit the number of expensive vibratory feed systems used in an automated machine, like the terminal feeder above, by maintaining the orientation of a part throughout the assembly process.

Commandment 8:

Don’t Try to Create a “Do All” Process or Machine

Just like when people try to multitask, when you try to do too much with one machine or during a single step in a process, the likelihood of mistakes or malfunctions increases.

From a machine design standpoint, processes and procedures should be broken down into simple steps that are strong and repeatable and not lengthy and complex. As a general rule, the simpler the processes are, the more reliable the machine will be.

For example, if you create an assembly automation tool, you should have one step to pick up the part and put a piece on, another step to flip the part over, and another step to perform the next part of the assembly automation process. By using simple steps and processes, setup and troubleshooting becomes straightforward so if something breaks, it’s easier and quicker to repair. In the end, don’t try to do it all in one shot—simplify.

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Processes that are arranged with a step-by-step methodology, like this circuit board processing line, are easy to understand and increase reliable in an automated system.

Commandment 9:
When in Doubt, Upsize

When deploying a robot, sizing the robot for the correct payload is critical to achieving proper machine performance.

As humans, we are inherently programmed to want to save money upfront, and our first thought is not to think in terms of future or long-term costs when making a purchase. But, this way of thinking is counterintuitive when it comes to the development of a single machine that can cost hundreds of thousands of dollars.

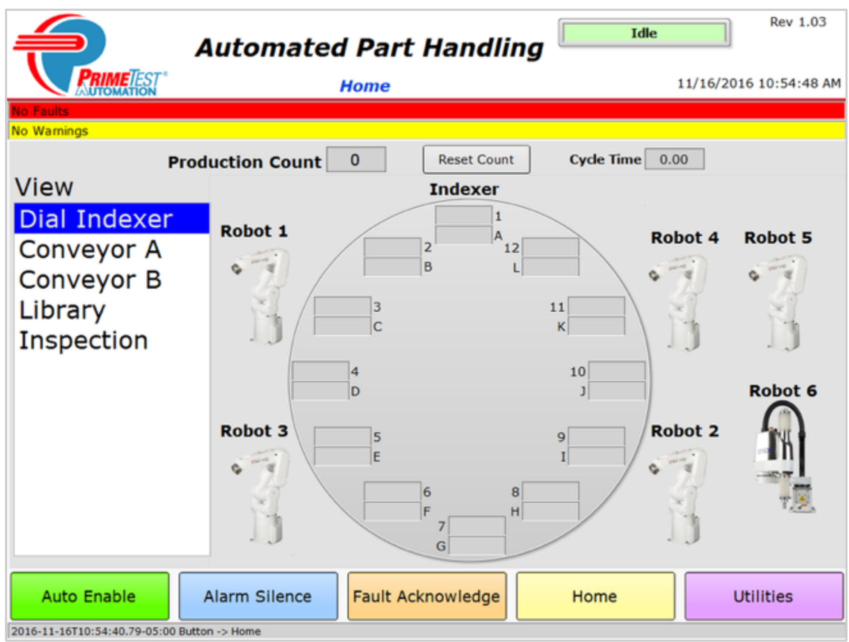
Let’s look at this more closely with an example of a machine that presses two parts together using an air cylinder with 5 lbs of force. This air cylinder costs $100 and cannot exceed 5 lbs of pressure, which meets the current requirement. There is also an air cylinder available that can use up to 20 lbs of force that costs $120. Instead of spending $20 less and designing the machine to just meet the minimum force requirements for this current application, in this instance, it’s better to “upsize” the part and use the air cylinder that can apply up to 20 lbs of force.

By doing this, you are not only designing the equipment for a potential change in future requirements, but you are building a more forgiving system that can handle potential challenges like a drop-in air pressure at the customer’s facility or a plastic part that’s interference fit increases as molds and tooling wear. In this case, not only is this $20 price difference negligible in relation to the cost of the entire machine, but the cost associated with upsizing this part from the beginning is minimal compared to the cost of rebuilding a marginal process down the line.

Commandment 10:
Just Because You Can Write Software for a Function, Doesn't Mean You Should

When it comes to the software side of machine design, engineers tend to want software that can address every possible scenario. While it is good to be prepared, a lot of the time, we see requests for unnecessarily complex programs to address scenarios that are highly unlikely to occur.

Since the control software will ultimately be used by operators that were not involved in the development of the machine, it is important to avoid unnecessary complexity and to create a program that is easy to use. Overall, think about what is essential for the operator to know and keep the software straightforward.



Software that is easy to use, like this automated part handling system interface, will help ensure seamless operation for your system once it is deployed.

Building the Best Automated Machines Requires Best Practices You Believe In

At PrimeTest Automation, we may not have these commandments posted on the wall of our shop, but these best practices are agreed upon and engrained into every one of our engineers. We know that to keep our customer's production systems consistently functioning, it is important to design and develop machines with minimal downtime and ultimate reliability. Thus, we focus on having proper foresight and use these commandments to focus on simplicity, verification, and risk mitigation to develop automated machinery that is built to last.

The PrimeTest team developed and adopted the 10 commandments of automation to ensure that we continuously deliver automated solutions that that meet our customers' aggressive requirements and goals.

Learn More About Clients Who Have Been Successful Using the PrimeTest Automation Approach at http://info.primetest.com/case-studies

About PrimeTest

PrimeTest Automation is a full service systems integration company with a talented in-house engineering team featuring mechanical, electrical, and software engineers. All systems are modeled using the latest in 3D design software, thoroughly reviewed with the customer, and manufactured in our facility located in Boca Raton, Florida. PrimeTest Automation offers a complete set of electrical, mechanical, and pneumatic drawings with each system as well as detailed operations and maintenance manual. On-site training services are also available.