



HOW FULLY INTEGRATED MOTION CONTROL SOLUTIONS ARE THE SECRET WEAPON OF WET PROCESSING & WASHDOWN ENVIRONMENTS

INTEGRATED SOLUTIONS

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Integrated motion control systems save design time and money for machine builders in any industry, but provide a special set of benefits for those machines built for wet processing and washdown environments.

Washdown Environments

Washdown environment is the term for any production setting where the machinery must be rinsed, usually with water or chemicals or a mixture of the two, in order to clean the machinery for a different process or at the end of a production batch. The definition of 'washdown' varies widely, ranging from a simple water rinse performed manually to a multi-step, high-pressure cleaning process that is itself automated and highly controlled. Industries commonly using washdown techniques include medical manufacturing, semiconductor, packaging and the food and beverage industry.

Due to media attention in recent years regarding contamination, the food, beverage and packaging industries have been under more intense scrutiny with higher standards than ever. The poultry industry, for example, laments that, "Although robot manufacturers have focused for years on penetrating key areas of food processing plants, high-pressure cleaning requirements have limited their use in fresh processing areas of meat and poultry plants. This type of washdown typically involved the daily sanitizing of processing equipment with high pressure water and highly corrosive cleaning agents." At the same time, the proliferation of compact automation equipment and, more specifically, integrated motion control systems has not been ignored by system integrators who build for washdown environments.

IP Ratings

In these competitive industries the correct IP specifications must be paired with the specific wash-down environment. Incorrect specifications could result in production downtime and high equipment replacement costs. From cabling to motors to the control cabinet, washdown environments demand attention to detail in the machine building process.

For motion control system selection purposes, one of the best references for washdown environments is the IP rating system (or IP code).

'IP' stands for ingress protection and is defined in international standard IEC 60529 which classifies and rates the degrees of protection for metal castings and electrical enclosures against solid objects, dust and water.

The IP code consists of the letters IP followed by two digits or one digit and one or two letters. The IP code helps to give concrete specifications to vague terms such as 'waterproof.'

The first number indicates protection against solid particles.

The second number indicates protection against ingress of liquid.

The larger the digit, the greater the protection offered.

IP TABLE REFERENCE					
FIRST DIGIT: Ingress of solid objects		Sample	SECOND DIGIT: Ingress of liquids		Sample
0	No protection		0	No protection	
1	Protected against solid objects over 50mm (e.g. hands, large tools).		1	Protected against vertically falling drops of water or condensation.	
2	Protected against solid objects over 12.5mm (e.g. hands, large tools).		2	Protected against falling drops of water at up to a 15° angle from normal orientation.	
3	Protected against solid objects over 2.5mm (e.g. wire, small tools).		3	Protected against water spray from any direction at up to a 60° angle from normal orientation.	
4	Protected against solid objects over 1.0mm (e.g. wires).		4	Protected against water splash from any direction.	
5	Limited protection against dust ingress (no harmful deposit).		5	Protected against low pressure water jets from any direction. Limited ingress permitted.	
6	Totally protected against dust ingress.		6	Protected against high pressure water jets from any direction. Limited ingress permitted.	
Example: SM23165M-IP65 (NEMA 23) The two digits represent different forms of environmental influence: • The first digit represents protection against ingress of solid objects. • The second digit represents protection against ingress of liquids.			7	Protected against short periods of immersion in water 1m deep for up to 30 minutes.	
IP 65			8	Protected against long periods of immersion in water. Motors are hermetically sealed.	

Note: Moog Animatics does not currently support any products rated above IP65. Please consult Moog Animatics or a Moog Animatics authorized distributor directly to confirm products that are IP rated. You can reach Moog Animatics at (408) 748-8721.

IP Ratings

For gentle washdown environments, specified components will need an IP54 or higher rating. With an IP5X or IP6X, the first digit means that the electrical enclosures are dust protected or dust tight, respectively.

The IP rating system is only used for water and non-caustic liquids.

The first digit is important because in a washdown environment, production may be exposed to solid particulate that cannot remain on the machines over long periods of time.

This could include: fine wood, powder, metal or paper particulate, feather pieces from poultry processing or food debris and byproduct from food processing and packaging facilities.

The second digit of the IP rating is the more important metric in choosing an IP rated product for a washdown environment. As you can see in the table on the previous page, ratings of the second digit specify washdown intensity ranging from vertical dripping water to complete immersion.

It's important to note that in some food processing and marine applications, washdown environments include reactive chemicals such as chlorines and acids which cause moving parts to wear down faster than expected. Often synthetic materials such as plastics or stainless steel are used in addition to chemical passivation to prevent or slow corrosion.

In most scenarios, washdown environments will need an IP65 or higher rating. An IPX5 rating means that the electrical enclosures are protected against jets of water from any angle. However, an IPX6 rating will give protection against strong jets of water from any angle. It is typically not recommended that IPX4 rated equipment be used when building machines for washdown environments because of the inconsistency between definitions of words such as 'splashed' and 'sprayed'. However, if the machine will be immersed in water in any way, an IPX6 or higher rating will be needed. IPX7 is the highest defined level of water protection offered, meaning that the electrical enclosures can be immersed in water up to 1m deep for 30 minutes with no harm coming to the electronics.

Chemical passivation is a technique used to combat caustic liquid environments but is not included in IP specifications.

Common Washdown Environment Problems

Cabling

Integrators, systems houses, OEM machine builders, and component vendors all agree: cabling is the single most common point of failure in motion control systems. If a motion system is to perform as required and last, the wire harness requires informed design, specification, and installation. Traditionally a minimum of two sets of wires are needed for a motion control system: one for power transmission and one for communications.

In washdown environments, often cabling is extended longer distances than usual to keep the control cabinet away from possible liquid exposure, saving on the costs of buying control components that are IP rated. However other problems occur when the cable is not properly installed (terminating cables with a clamp, connector located too close to a flex point, ensuring proper bend radius), and the more cables installed, the higher the risk of a mistake that leads to failure.

If cables are exposed during the washdown process, water can seep into the insulation and short out the signal. While specifying an IP motor or controller will be straightforward, the degree of standardization tends to fall off when choosing cables and connectors.

The rate of failure of a cable is directly proportional to the cable's length of travel.

Temperature and Humidity

Temperature and possibly humid conditions should be taken into account when building a machine for a washdown environment. If the washdown liquid is at a hotter than ambient temperature (such as for the minimization of bacteria in food and beverage industries), not only will some cable material wear out faster but steam from the wash could penetrate into motion control equipment even if that particular component is not directly in the water.

In addition, cold temperature environments (such as in juice filling machines where contents cannot rise above a given temperature) pose the risk of condensation. If water condenses on the encoder read head, your motor will stop working.

Water vapor ingress is another less known but potentially hazardous danger in even latent humid conditions. Motors and drives alike create heat when they run, warming and expanding the air inside the component. When the components are then powered off, such as at the end of the day, air inside the component cools and creates a negative air pressure that pulls in any latent water vapor inside unsealed crevices.

Often water vapor ingress is not enough to completely ruin electronics inside motors and drives, but it can cause delays that add to costly lost manufacturing time upon startup if the situation is not remedied.

Common Washdown Environment Problems

Component Connection Points

The more cables that exist in a system, more connection points are created. And with more connection points comes higher chances of failure because a larger number of potential leakage points are created. Specifically in washdown environments, ensuring that all electrical connections between components that may come in contact with fluid are IP rated is important to reduce failure rates.

Each hole in the machine adds another point of possible ingress of fluid, meaning higher labor costs and more maintenance time to ensure longevity of the machine in a wet environment.

Machine and Machine Replication Costs

Machine costs are always a concern when building a machine that must be replicated multiple times for customers. In washdown environments, two of the areas where costs soar are cabling (discussed earlier) and wall penetrations from the wet to dry environments.

Take this example: A boat sitting in water needs a depth finder to be installed which requires a hole in the bottom of the boat. Suppose the boat requires a hydrometer as well, which means two holes in the bottom of the boat. Every time a hole is drilled from the dry environment to the wet environment, the chances increase that one of the holes will leak. Ultimately, by minimizing the total number of holes in the boat, you decrease total labor cost and decrease the chance of failure due to fluid ingress. The same principle can be applied to machine design.

When designing a machine for a washdown environment, a packing gland (a means to seal cables through the hole) is needed for each hole that will be fed through with cables/parts. Each packing gland adds to the total machine cost, and drilling each hole adds labor costs. For multiple machines that need to be built, each hole added from dry to wet environments in the design adds an additional cost to the machine.

What Does 'Integrated Servo Motor' Mean?

The growing trend in automation is integration. Integrated products save money by reducing cabling costs, design and test time, and labor costs, and ultimately get the machine to market faster because of these advantages. Some skeptics will say 'don't pay for more than you need' in reference to integrated servo motors. What they neglect to mention is that all of the separate components you need to run a complete motion control system after factoring in cabling costs, labor costs and extra costs of washdown rated housing for all those separate components far outweighs the total cost of an integrated motion system.

In the end, a conventional motion control system will cost you more than using an integrated solution for most washdown environments.

Integration is not only gaining popularity in manufacturing at the component level with drives, motors, communications and controllers and gearheads but also at the higher level as we move toward more single programming environments. The term 'integrated servo motor' doesn't have a strict definition, leaving many different types of integrated motors being lumped together into the same category.

Below are the two types of motors and component combinations often deemed 'integrated servo motors.'

Motor + Drive + Communications

The most common type of 'integrated servo motor' is a motor with a servo drive or amplifier integrated into the motor housing and often includes the encoder and communication ports. These types of motors do not include the motion controller, leaving the user to choose their own single or multi-axis controller. Unfortunately, this option still leaves the user having to install a cabinet to house the controller, though it may be a smaller cabinet considering that the servo drive is already integrated inside the motor.

Controller + Motor + Drive + Communications

This other type of 'integrated motor' is fully integrated with the motion controller, servo drive or amplifier, encoder and communication ports: all the essential parts of a complete motion control system. This system can be deceiving though, because by simply looking at the outside of the motor it is not possible to determine that there's a motion controller board inside the motor housing. This type of motor can completely eliminate the need for a control cabinet, since all of the drives and controllers are inside each motor. These motors are said to be more reliable because there are fewer parts that need to be cabled together. Reduced costs come as the result of less cabling and wiring and fewer components to specify in the machine.

How Smart Is Your Controller?

Not all fully integrated motors are the same, though the manufacturer may claim to have the same main components integrated. Below are three basic levels of controllers and their associated capabilities

Basic Integrated Controller

Many integrated motors feature simple motion controllers that are only desirable for single axis applications that can execute basic moves and perhaps take in a few points of I/O and initiate motion. These integrated motors are usually lower cost than integrated motors with more advanced motion control capabilities. The integrated motor with the basic controller will still require a separate controller for multi-axis applications.

Midlevel Integrated Controller

A midlevel functionality motion controller on an integrated servo motor has more capability than a basic controller including performing basic move profiles, having more available I/O and possibly even sending and receiving messages to and from a PLC. Many can run simple user-created programs as well. However, as with the basic controller most of the machines will still need a separate external controller to be able to perform advanced move profiles or run a multi-axis machine.

Advanced Integrated Controller

Fully integrated servo motors with advanced controllers would provide the most benefit to machines built for washdown environments. Because these integrated servo motors don't require a separate controller (or control cabinet) even for multi-axis machines, much of the cost and complexity is reduced compared to conventional systems or even integrated servomotors with basic or midlevel controllers. Integrated servo motors with advanced controllers can perform complex coordinated motion, feature floating point math and are infinitely scalable. Additionally, they are able operate larger amounts of remote I/O devices required on most machines. Moog Animatics' SmartMotor is an example of a fully integrated servomotor with an advanced controller.

Washdown Environment Solutions

Fully Integrated Servo Motor with Advanced Controller

Cabling

Cabling is the most common point of failure in motion control systems, and costs of specifying wash-down rated cabling as compared to non-washdown cabling can become immense. However, with a fully integrated servo motor you can reduce costs in many places without sacrificing performance.

Because of the integrated nature, fewer cables are needed to and from each motor in the machine. A three-axis machine with three non-intergrated motors probably has at least six cables, one drive power and one feedback/communications cable for each servo motor in the system.

An integrated servo motor with advanced controller, such as the SmartMotor, can route power and communications from one integrated servo motor to the next with only one pair of cables running from the machine to the control cabinet (if a control cabinet is used at all). That would be a 66% reduction in cabling costs just for a three motor system.

With some integrated servo motors with advanced controllers, such as SmartMotors, up to 120 integrated servo motors may be placed onto a CAN network with still only one pair of cables running from the master motor to the control cabinet. Less cabling also means less chance of liquid ingress in a washdown environment.

Temperature and Humidity

To protect against humidity and condensation, IP motors should be specified even when the motors are not in direct contact with the washdown fluid but near the washdown area. Be sure to consider operating temperatures of your application before choosing an IP rating. The SmartMotor, for example, is available in both IP65 and IP67 specifications and has a normal operating temperature range of 0C - 85C*.

To protect against water vapor ingress, one can always specify an IP65 or higher rated motor. However, another option is to make use of dielectric grease in the connectors and specify connectors with double O-ring seals. This will protect against water vapor ingress or possible corrosion of connector pins, ensuring that no downtime is experienced that could have been avoided.

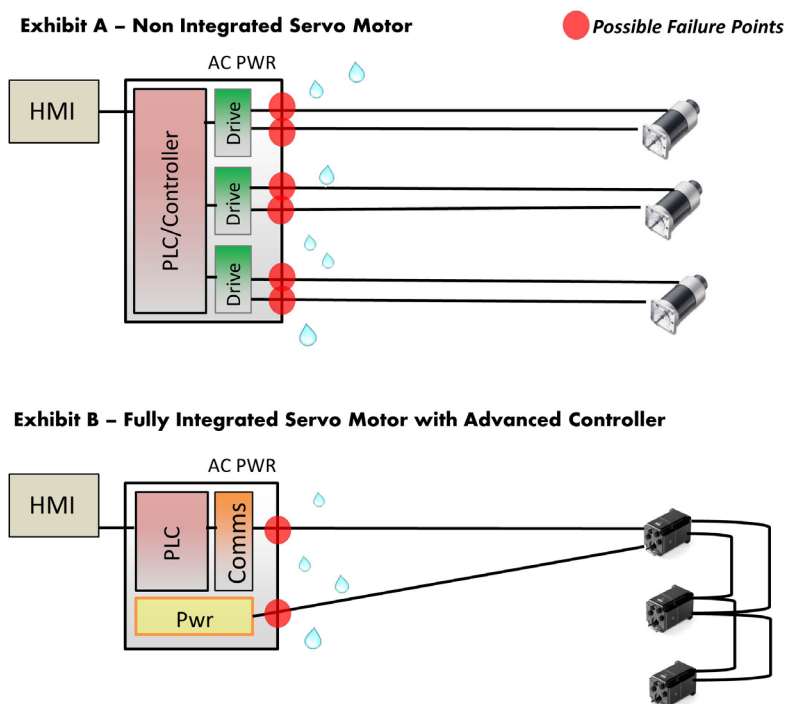
* NOTE: Power must be derated linearly from 25C - 85C.

Washdown Environment Solutions

Fully Integrated Servo Motor with Advanced Controller

Component Connection Points

The higher the number of Connection points from wet to dry environments comes with a higher chance of failure. Fully integrated servo motors with advanced controllers are one of the best kept secrets of system integrators building machines for washdown environments. **With fully integrated SmartMotors, you can daisy chain power and communications cables so that only one pair of cables is permeating the control cabinet instead of a pair of cables for every motor.** In looking at the diagram below, note that the number of connection points is reduced significantly when using a fully integrated servo motor. The more motors in your machine, the more chance of failure if a conventional motion control system is used in a washdown environment.



Machine and Machine Replication Costs

For washdown environments, two of the areas where costs soar in machine building are cabling (discussed earlier) and wall penetrations from the wet to dry environments. As discussed previously, a fully integrated servo motor means there are fewer parts to connect and overall less cabling compared to a conventional system. Fewer cables lower total machine cost, and when machine replication comes into play even a small cost savings can multiply exponentially for the system integrator.

As most machine builders will admit, labor costs are not linear. From the previous example of drilling holes in a boat for different pieces of equipment, additional holes require additional labor costs. When the total number of holes is decreased the amount of labor that's required is proportionally decreased. Instead of three people drilling twenty holes in each machine, it could take only one person drilling eight holes in all the machines. Instead of taking six to seven months to build 100 machines, it will only take two months. Labor costs and time to market can be significantly reduced for washdown environment machines when fully integrated servo motors, such as the SmartMotor, are used.

SmartMotor Solutions

Successful Applications in Washdown Environments

Bottle Filling & Capping for Packaging Industry

Challenges:

- IP65 or higher rating
- Small factory floor space
- Maximum 50V to reduce shock hazard

Situation

An international consumer goods company needed to fill, cap and package multiple sizes of detergent bottles. The most efficient method was to place the bottles into the box first, and then fill and cap them. Because of the wet conditions, IP65 or higher rated systems were preferred. The existing machine used manually operated hand wheels to adjust the filling lines up and down depending on bottle height, and adjust the distance between fill heads on the grid based on bottle volume.

Problem

In keeping with the highest OSHA standards, the manufacturer wanted a maximum 50V motion control system to minimize risk of shock in the wet processing environment. In addition, factory floor space was limited but high levels of output needed to be maintained. The machine needed to be adjustable on the fly for different bottle heights and proper cap positioning, but the current manual adjustment was time consuming, leading to unacceptable throughput and increased costs of machine operators. Distance between fill heads also needed to be adjusted for different batches as larger bottles were spaced farther apart within their boxes. Manual adjustment was not fast or efficient. In order to increase throughput and remain competitive in the market, downtime between batches had to be reduced.

Solution

Using IP65 rated SmartMotors, the machine was redesigned to adjust rack bars based on I/O from sensors for each bottle size. SmartMotors were also used to adjust the entire height of the conveyor line based on bottle size significantly decreasing downtime between batches. Because SmartMotors operate between 24V-48V, shock hazard was not an issue. Fill heads were set to adjust to the proper pitch and spacing based via sensors detecting bottle size. Adjusting the processing line to fit multiple bottle sizes and decreasing overall size of the control cabinet by using the integrated SmartMotor decreased the factory footprint of the total machine as well as reduced worker exposure to dangerous machinery. The company also had no need to buy a step down transformer from 3 phase 480V AC down to 240V AC or less, Switch Mode supplies were available providing 480 3 phase to 48VDC directly. This resulted in decreasing total cost of ownership.

If you'd like to discuss how the SmartMotor integrated servo motor with advanced controller could lower your total machine BOM or easily streamline your application, call us today at (408) 748-8721 or email us at sales@animatics.com.

You may also request a free copy of Moog Animatics catalog here:
<http://www.animatics.com/request-catalog.html>

Moog Animatics www.animatics.com
3200 Patrick Henry Drive Santa Clara, CA 95054
Tel: (408) 748 8721 Fax: (408) 748 8725 E-mail: sales@animatics.com

