

Integrated Solutions for Harsh Environments

- Public safety and tightening standards drive the need for washdown capable equipment used in food, medical, and other industries
- Equipment IP ratings appropriate for the application must be considered in the machine design
- Washdown protection must be available not only in motors but also interconnect cables and other system components in or near the washdown area
- Fully integrated servos can greatly reduce additional costs and failure points that non-integrated servos would encounter for washdown compliance

Washdown Environments

“Washdown environment” is the term for any production setting where the machinery must be rinsed, usually with water, 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 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 washdown 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 helps to give concrete specifications to vague terms such as “waterproof”. Typically, the code consists of the letters IP followed by two numbers (e.g., IP65):

- The first number (0-6, or X) indicates protection against solid particles
- The second number (0-8, 9K or X) indicates protection against ingress of liquid

The larger the digit, the greater the protection offered. Optionally, there can be one or two letters to indicate personnel and/or machine protection.

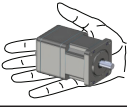

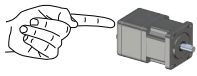


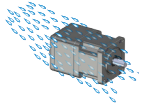

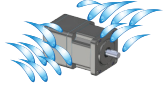
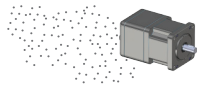
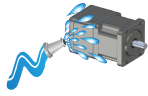
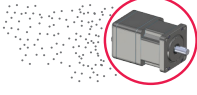

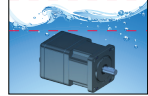
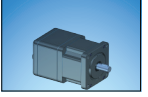

IP RATING REFERENCE			
FIRST DIGITAL: Ingress of solid objects	Sample	SECOND DIGIT: Ingress of liquids	Sample
0	No protection	0	No protection
1	Protected against solid objects over 50 mm (e.g., hands, large tools). 	1	Protected against vertically falling drops of water or condensation. 
2	Protected against solid objects over 12.5 mm (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 2.5 mm (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 1.0 mm (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. 
<p>Example: SM23165M-IP65 (NEMA 23)</p> <p>The two digits represent different forms of environmental influence:</p> <ul style="list-style-type: none"> • The second digit represents protection against ingress of liquids. • The first digit represents protection against ingress of solid objects. <p>IP 6 5</p> <p>NOTE: Moog Animatics currently manufacturers certain products rated up to IP67. Please contact Moog Animatics for details.</p>		7	Protected against short periods of immersion in water 1m deep for up to 30 minutes. 
		8	Protected against long periods of immersion in water. Motors are hermetically sealed. 
		9K	Protected against very high pressure, high temperature jet/steam cleaning. 

Figure 1: IP Rating Reference

Refer to the previous figure. 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.

NOTE: 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 particulates that cannot remain on the machines over long periods of time. This could include fine wood, powder, metal or paper particulates, 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.

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

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". If the machine will be immersed in water in any way, an IPX7 or higher rating will be needed. IPX9K is the highest defined level of cleaning protection offered, meaning that the electrical enclosures can be cleaned with very high pressure, high temperature spray or steam with no harm to the electronics.

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. Typically, 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, cabling is often extended longer distances than usual to keep the control cabinet away from possible liquid exposure, which saves the costs of buying control components that are IP rated. However, other problems occur when cables are not properly installed (e.g., terminating cables with a clamp, locating

a connector too close to a flex point, overlooking proper bend radius). Further, as more cables are installed, there is increased 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.

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

Temperature and Humidity

Temperature and humidity should be taken into account when building a machine for a washdown environment. If the washdown liquid is hotter than the 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 equipment is not directly in the water.

In addition, cold 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, the motor will stop working.

Water vapor ingress is another less known but potentially hazardous danger in even latent humid conditions. Motors and drives 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 any latent water vapor into unsealed crevices.

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

Common Washdown Environment Problems

Component Connection Points

As more cables are designed into a system, more connection points are created. Those connection points create higher chances of failure because of a larger number of potential leakage points. Therefore, to reduce failure rates in washdown environments, it is important to

ensure that all electrical connections are IP rated between components that may come in contact with fluid.

NOTE: 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 for customers that must be replicated multiple times. 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 or parts. Each packing gland adds to the total machine cost, and drilling each hole adds labor costs. For multiple machine builds, the design becomes more critical, as each hole added from dry to wet environments adds more material and labor costs to the machine replication.

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. However, 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 servo motor” is fully integrated with the motion controller, servo drive or amplifier, encoder and communication ports; i.e., all the essential parts of a complete motion control system. Be aware that this system can be deceiving, 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. The following 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. It may include: 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. The Moog Animatics SmartMotor™ is an example of a fully integrated servomotor with an advanced controller.

Washdown Environment Solution: Fully Integrated Servo Motor with Advanced Controller

Cabling

Cabling is the most common point of failure in motion control systems, and costs of specifying washdown 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-integrated motors likely has at least six cables, with 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 servo, 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 (that is, if a control cabinet is used at all). That would result in a 66% reduction in cabling costs for a three motor system, with even greater savings for systems having higher motor counts.

NOTE: For some integrated servo motors with advanced controllers, such as SmartMotor servos, 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.

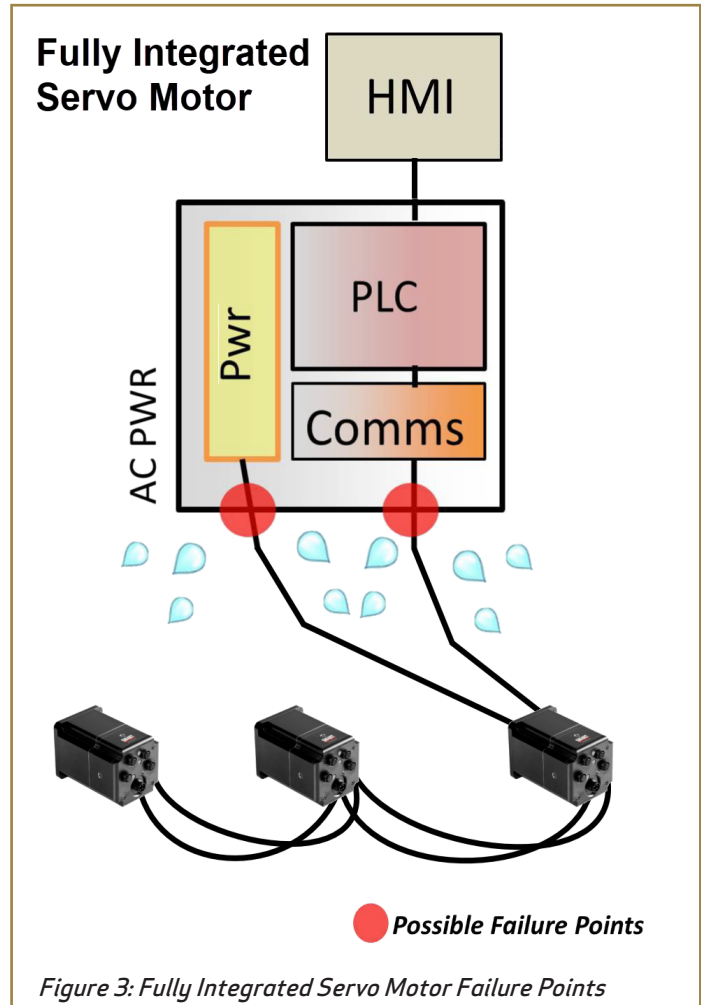
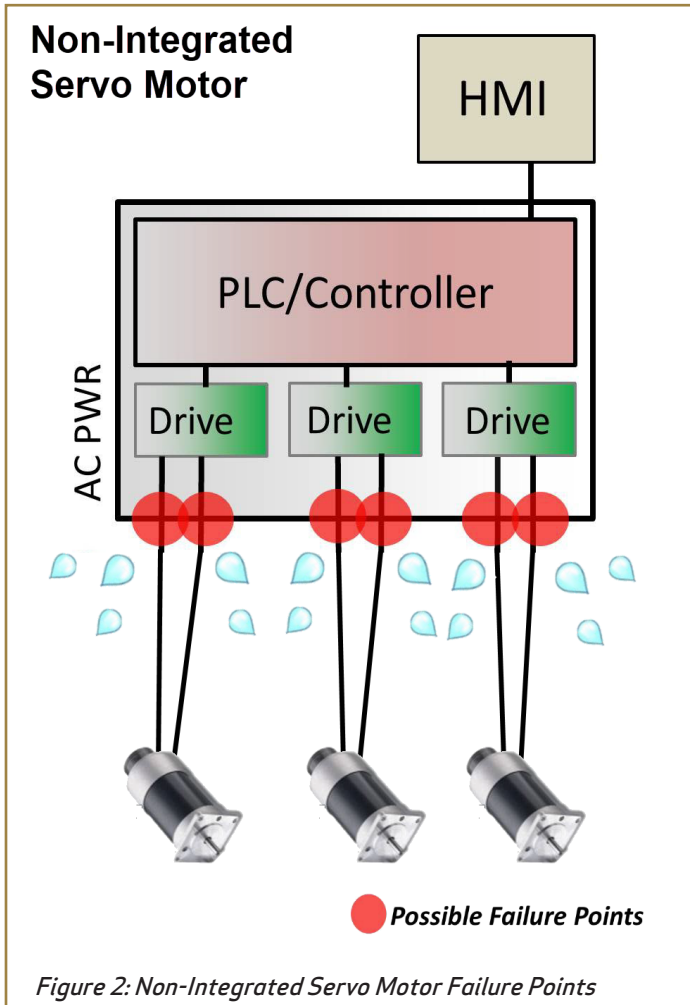
Humidity and Condensation

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 are near the washdown area. Be sure to consider operating temperatures of your application before choosing an IP rating. The SmartMotor servo, for example, is available in both IP65 and IP67 specifications and has a normal operating temperature range of 0°C - 85°C. (Power must be linearly derated from 25°C - 85°C.)

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.

Component Connection Points

A higher 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 who build machines for washdown environments. With fully integrated SmartMotor servos, you can daisy chain power and communications cables so that only one pair of cables is entering the control cabinet instead of a pair of cables for every motor. Compare the diagrams in figures 2 and 3, and note how the number of connection failure points is reduced when fully integrated servos are used.



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 required is proportionally decreased. For example, 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.

Application: Bottle Filling and Capping for Packaging Industry

Challenges:

- IP65 or higher rating
- Small factory floor space
- Maximum 50 V 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 50 V 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 SmartMotor fully integrated servos, the machine was redesigned to adjust rack bars based on I/O from sensors for each bottle size. SmartMotor servos were also used to adjust the entire height of the conveyor line based on bottle size, which significantly decreased downtime between batches. Because SmartMotor servos operate between 24-48 VDC, shock hazard was not an issue. Fill heads were set to adjust to the proper pitch and spacing based on 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 servo 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 three-phase 480 VAC down to 240 VAC or less, Switch Mode supplies were available that directly provided 48 VDC output. This resulted in decreased total cost of ownership.

Figure 1	IP Rating Reference provided by Moog
Figure 2	Non-Integrated Servo Motor Failure Points provided by Moog
Figure 3	Fully Integrated Servo Motor Failure Points provided by Moog

About Moog Animatics

Since 1987, Moog Animatics has been designing, manufacturing and marketing motion control products. We bring total automation solutions to numerous industries, including semiconductor, defense, automotive, aerospace, biomedical, textile, security, marine sciences, packaging and many more.

When you need an innovative solution, you need Moog Animatics. We pride ourselves on offering the most creative and complete answers to your motion control questions.

The Moog Animatics headquarters is located in the heart of Silicon Valley, with international offices in Germany and Japan, and a vast network of Moog Animatics-trained Automation Solution Providers around the world.

For more information on how the SmartMotor integrated servo with Combitronic technology can benefit your application, please call 650.960.4215 or email us at animatics_sales@moog.com.

For product information, visit www.animatics.com

For more information or the office nearest you, contact us online, animatics_sales@moog.com

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