



KUKA ROBOTICS CORPORATION

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# ARCTIC ROBOT DESIGN GUIDELINES

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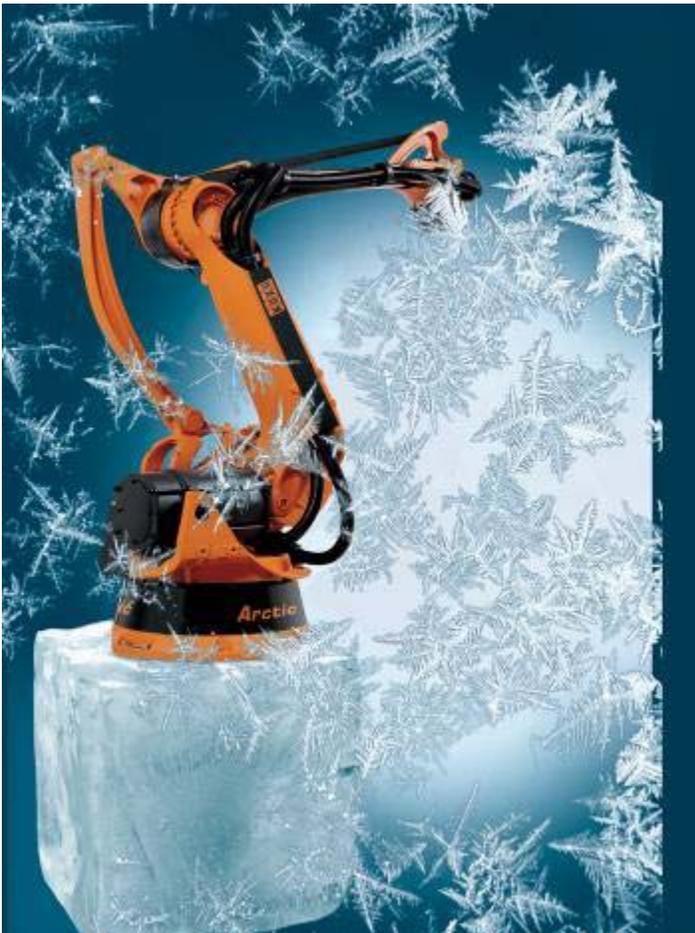
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Revision 1.1

## Arctic Robot Design Guidelines

Quick – think about an inhospitable environment where a robot should be deployed, an application that saps productivity, challenges workers, increases injuries, and increases costs. Most manufacturing professionals would think of die casting, forging, welding, grinding, painting – applications that are typically hot, dirty, noisy, and dangerous.

Now go the other direction, and think about the ice cream you had last night, and think about the freezer where it was poured, case packed and palletized. The industrial freezer environment is an unfriendly, demanding place for people to work, and a perfect application for robotic automation. Unfortunately, until now there were no robot systems designed from the ground up for freezer applications. KUKA changed that in 2004 with the introduction of the first robot designed specifically for applications in hard freeze environments, the KUKA KR 180 PA™ Arctic Palletizing Robot.



Frozen food has been a staple in American households since the mid '50's when it was introduced. And the growth of the frozen food market continues today, in the US and Europe, as processes get better at delivering fresh flavors, and our life styles remain hectic. According to an NPD Group, Inc. report, the frozen meal category has continued its steady growth over the past 10 years. Total retail sales of frozen foods in the U.S. reached more than \$26.6 billion in 2001, 6.1 percent higher than 2000, up over one billion dollars from 1999 and two billion dollars from 1998. At more than \$40 billion in annual sales, frozen foods represent roughly one-third of total foodservice sales. There is also growth in partially processed food for institutional and home use – food that is partially cooked and then flash frozen to be finished off just prior to consumption.

Processing and packaging any frozen food presents challenges. Depending on the food, 30% to 100% of the manufacturing processes must be executed in a hard freezer environment. Manufacturers must keep tight control on the freezing process, and must deal with extraordinarily

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high labor costs. The biggest driver to labor costs is the ability of workers to spend extended periods in the freezer environment. According to a Danish food administration report frozen foods must be maintained at -12°C and quick frozen foods at -18°C. Workers must be provided adequate rest periods outside the freezer environment to warm up, and this often entails hiring 2 or 3 staff to work a single freezer position.

And if 2x to 3x increases in direct labor costs weren't enough, some companies report higher incidence of illness and sick time, as well as higher workers compensation claim rates. A food manufacturing industry report posted on [www.collegegrad.com](http://www.collegegrad.com) states that in 2002, there were 9.3 cases of work-related injury or illness per 100 full-time food manufacturing workers, much higher than the rate of 5.3 cases for the private sector as a whole. Injury rates vary significantly among specific food manufacturing industries, ranging from a low of 3.8 per 100 workers in flavoring extracts and syrups plants to 14.9 per 100 in meat packing plants, the highest rate in food manufacturing.

All frozen foods present some degree of challenge, and opportunity for flexible automation. But the ice cream industry may be the most demanding environment that stands to benefit the most. Temperature is critical in the manufacture of ice cream, and the entire process must be performed in a hard freeze environment. The product must be flash frozen to control sanitary conditions, and the environment is among the coldest of all freezer applications.



Frozen food manufacturers have tried to automate in the past with traditional packaging and handling automation, but with mixed success. In some cases the traditional equipment lacked the flexibility required in today's manufacturing environment of expanding product lines, constant changeover, and rapid market changes. In other cases the footprint of traditional equipment becomes prohibitive – floor space in a freezer environment is painfully expensive to build and operate. But in most cases, the equipment just can't stand up to the freezer environment, suffering from ongoing performance and maintenance issues.

One work-around approach has been to shuffle the frozen product in and out of the freezer environment for packaging and palletizing operations. Unfortunately, in some cases this can directly reduce quality, especially in palletizing applications. While a primary pack operation is

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relatively quick, building up a full pallet takes far more time, and may compromise quality. Some companies try to work around this limitation by staging product in the freezer before sending it out for palletizing, and immediately returning the full pallet to the freezer. This approach requires expensive freezer space, and still represents a quality risk.

Enter robots: highly flexible, more efficient with expensive floor space, and the clear future in packaging and palletizing. Unfortunately early robot efforts meant taking a standard industrial robot and trying to shove it into the freezer environment. One approach has been to bag the robot – enclosing it in a flexible bag and blowing heated air to maintain working temperature. Another approach has been to insert a heater in the base of the robot. Both approaches have major limitations, including increased maintenance, the cost of ongoing consumables and increased operating costs, and compromised performance.

With the introduction of the KUKA KR 180 PA™ Artic Robot, the industry has a clear alternative for automating packing and palletizing processes in hard freeze environments. The KUKA Artic robot was designed from the ground up to operate reliably over a full life cycle, with no performance compromise, in hard freezer environments.

Deploying automation in a hard freezer environment requires a new approach to systems engineering. The following are 10 basic design guidelines for freezer applications.

1. Don't compromise on the robot. To ensure a proper operating life cycle, with minimal maintenance, be sure the robot is really designed for freezer applications.
  - a) Gear trains will require different tolerances, clearances, and in some cases, different materials.
  - b) Low temperature lubricants will be required to deliver long term performance and viscosity in the freezer environment.
  - c) Low temperature seals must be engineered into every joint to ensure proper seal and life cycle.
  - d) Dress packages – the routing system for hoses, power and signal cabling - must be designed to withstand extreme temperatures while maintaining flexibility and operating life. Care must be taken in designing the routing for dress packages, as friction points and flex points have greater impact on the material at low temperature.
  - e) On board electronics must be designed for extended life at sub zero temperatures. Normal design standards on PCB boards will result in higher failure rates due to cracked solder joints. Cable connectors require different housings and closures.
  - f) Teach pendants are especially susceptible, as keyboards, touch screens and electronics fail. Plastic enclosures can become brittle in extreme cold, and susceptible to breakage.
2. Consider vacuum actuated actuators for end of arm tools. Compressed air is expensive to dry, and can still cause condensation and water crystals that foul lines, actuators and valves.
3. To ensure proper actuation and avoid problems caused by sluggish springs and bellows, use positive displacement dual action solenoid valves.

4. Gripper design is still very product dependent. Vacuum still first choice, but the operating range and life cycle of suction cups should be confirmed. And the actual performance of the EOA tool should be confirmed early in the design cycle, to ensure cell performance.
5. Design for cold temperature maintenance. Mechanics and technicians will have to perform all maintenance and change over operations while wearing gloves. can be completed with gloves on! Cell and robot design should allow for easy access with tools in gloved hands, and connectors should be selected accordingly. And all lubrication should be dry lubes – temperature rated for the environment.
6. All system components should be designed to support clean up activities. Refrigerated environments mean wash down ready, while a freezer environment means wipe down only.
7. Peripheral devices must meet the freezer environment design specs. Check that conveyors, motors, controls, transmissions, gearboxes can perform in the environment.
8. Everything operates slower – plan on it. For example, grippers will operate slower, both friction, and vacuum styles. In packaging applications, it is typical to activate grippers on part approach to reduce cycle times. In freezer applications this isn't possible, as it's necessary to limit the amount of super cold air sucked out of freezer and through pumps and valves.
9. Don't base any of the system control logic on timing. Even though a well designed system won't require warm up cycles prior to production, the initial cycles each day or shift will run slower than a fully active system. Cycle timing will change, requiring the use of hard sensor logic.
10. Insulated floor typically has a layer of urethane insulation between two layers of concrete. Top layer often thin, non-reinforced concrete that isn't capable of holding a large robot stable. Be sure to install lag bolts through all layers to reach reinforced concrete capable of supporting an active robot.

For more information including technical details, how-tos, and specifications, [click here \(or cut and paste the url below into your browser\)](http://www.kukaregistration.com/packagingtoolkit.htm) to receive our comprehensive Robotic Guide on CD, Free!

<http://www.kukaregistration.com/packagingtoolkit.htm>

