

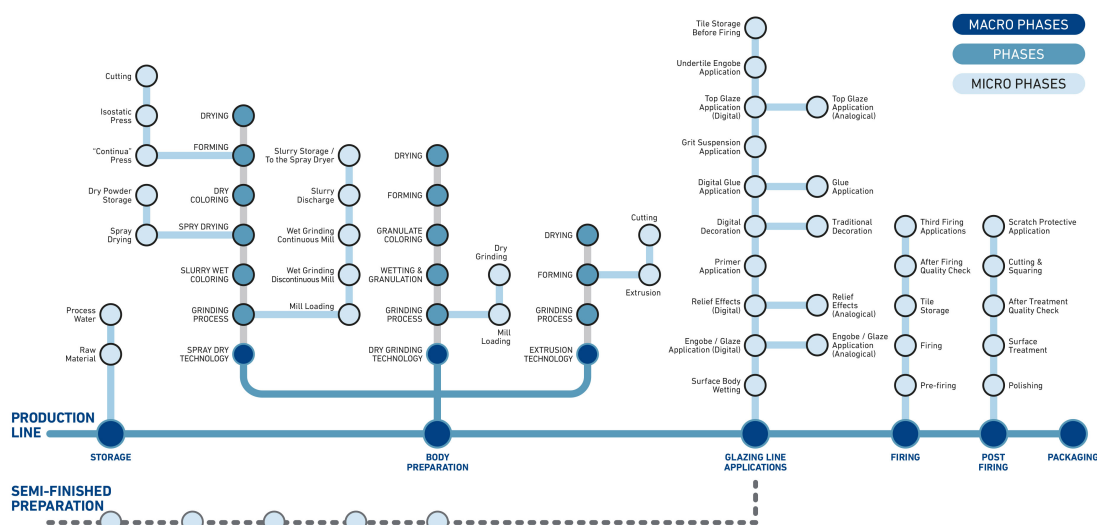


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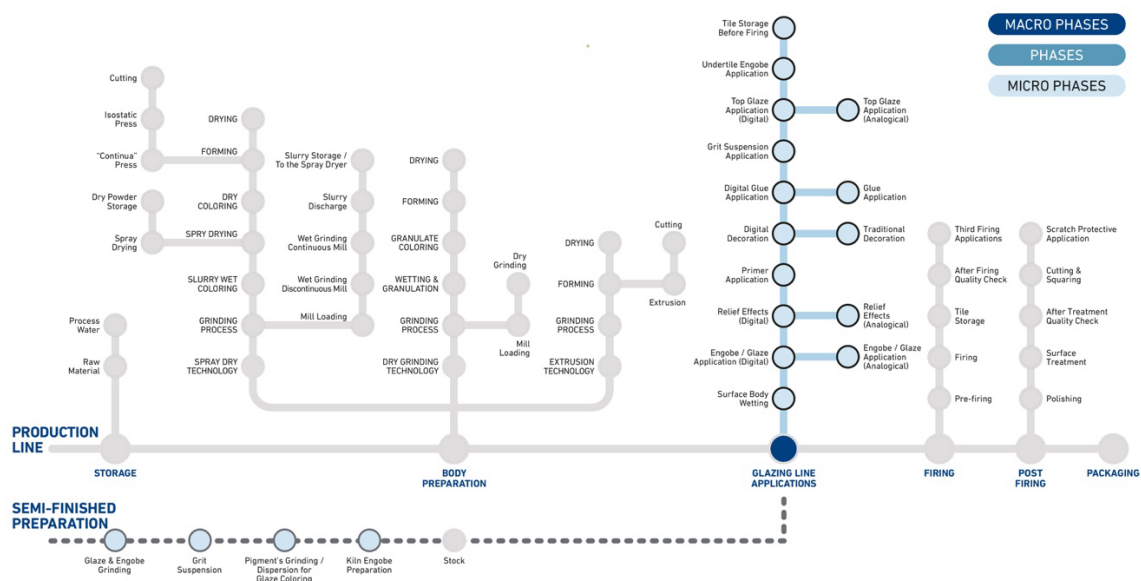
APPARENTLY INVISIBLE YET CONSTANTLY PRESENT

At every stage of the ceramic production process

A journey through problems & solutions



#66 WATER-BASED GLUES BY Z&S: DEVELOPMENT, TECHNOLOGY, APPLICATION





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1. Introduction and timeline

ZS's journey into water-based digital adhesives is the result of over a decade of research and development, rather than a recent trend. To understand the current level of technology, it helps to look back to the early 2010s.

Initial exploratory studies on inks and water-compatible chemistries began around 2013-2014, when the labs started testing the first formulations. This early work anticipated a technological shift that the market would fully embrace only years later. Focused development on digital adhesives formally began in 2017, leading to the launch of the first official product in 2018.

It's fair to say, with some pride, that ZS was among the pioneers in this field. The experience gained is not just theoretical—it has been grounded in practical testing since 2015, thanks to ink trials that paved the way. This head start allowed ZS to incorporate years of industrial feedback into today's formulations, making the current products the culmination of a long process of learning and refinement.

2. The range: a tailor-made approach

The current lineup of AQUABOND water-based digital adhesives—continuously evolving to keep pace with changing technologies and market demands—consists of five main products:

- AQUABOND F04
- AQUABOND F05
- AQUABOND F205
- AQUABOND F215
- AQUABOND Alpha 10

A natural question arises when faced with such a variety:
why so many different digital adhesives?

The answer lies in the complexity and diversity of customers' production lines. There is no universal glue because no production line is standard. Each customer has a unique combination of machines, print heads, and operating condition.

The guiding philosophy behind the range is customization. The glues are designed to fit specific "machine–print head" setups. This customization is not a luxury but a technical necessity: certain machine/head/process configurations require products with higher lubrication. Key features that differentiate the current range include:

1. Presence of fluxing material:
 - a. AQUABOND F contains it
 - b. AQUABOND ALPHA does not
2. Different solid content levels and types
3. Different chemical compositions
4. Varying leveling properties
5. Different interactions with granules



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6. Varying water content
7. Different operating temperatures

3. How much water does a water-based glue contain?

In today's market, often clouded by marketing labels, Z&S has set a clear technical and ethical benchmark for what qualifies as a "water-based" adhesive. For us, a product can only carry this label if it contains at least 20% water—a kind of threshold of technical and intellectual honesty.

Our formulations typically operate within a 20–40% water content range:

Product	Water-content
AQUABOND F04	40 – 42%
AQUABOND F05	25 – 27%
AQUABOND F205	25 – 27%
AQUABOND F215	25 – 27%
AQUABOND ALPHA 10	38 – 41%

This variability is intentional and necessary to balance the fluid's physical properties. It depends on the line's operating conditions.

For production lines running near the upper temperature limit (around 50°C), glues with lower water content are recommended, as they provide better lubrication to handle thermal stress.

On lines with greater control and lower operating temperatures (with cooler pieces passing under the digital bars), products with about 40% water perform exceptionally well. Long-standing products like Alpha 10 demonstrate that high water content can be used successfully when the system is well balanced and the production process is carefully managed.

4. Water content and lubrication: the "triad" principle

One of the most important technical insights is the inverse relationship between water content and lubrication. In the context of digital adhesives, lubrication refers, among other things, to the fluid's ability to flow smoothly, keep the print heads performing optimally, reduce friction, and prevent clogging.

The general rule is the less water a glue contains, the more lubricating it is. This is because reducing water increases the concentration of organic components (humectant solvents, binders, etc.) that give the fluid body and lubricating power.

From this perspective, and in broad terms, the AQUABOND range can be categorized according to this principle as follows:

- High-lubrication adhesives (low water content, ~20–30%): F05, F205, F215. Designed for print heads or machines that require a "richer," more forgiving fluid, especially under higher temperature conditions.



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- Lower-lubrication adhesives (high water content): F04, Alpha 10. Ideal for systems that can handle more watery fluids effectively.

It's essential to understand that there is no single "best" glue based solely on lubrication. The key concept is the Triad: Adhesive – Machine – Process Conditions, three elements that must align.

In general terms, high-lubrication adhesives with low water content, around 20–30%, such as F05, F205, and F215, are designed to ensure stability when piece temperatures range between 45°C and 50°C.

Glues with lower lubrication and higher water content, like F04 and Alpha 10, are instead ideal when incoming piece temperatures are kept low, around 40°C.

The Triad principle demonstrates that there is no one-size-fits-all solution: if thermal conditions are well controlled and kept low, high-water adhesives perform effectively, whereas if operating temperatures rise, a more lubricating adhesive becomes a technical necessity to maintain system stability.

5. The role of fluxing agents: types and considerations

The fluxing agent is a key component in some of our formulations, such as F04, F05, F205, and F215, while it is absent in others, like Alpha 10. Its primary function is to facilitate the melting and sintering of the grit applied afterward. Chemically, the flux consists of a mixture of solid ceramic materials in suspension that, during firing, interact with both the glaze and the grit, contributing to the result.

Product	Fluxing agent	Characteristics
AQUABOND F04	√	Gloss
AQUABOND F05	√	Gloss
AQUABOND F205	√	Matt
AQUABOND F215	√	Matt
AQUABOND ALPHA 10	---	---

The chemical composition of the fluxing agent directly affects the aesthetic outcome of the final product, resulting in different types of finishes. Glossy fluxes, found in AQUABOND F04 and F05, promote a shiny surface, while matt fluxes in AQUABOND F205 and F215 contain "mattifying" materials that reduce light reflection.

It's important to remember that the choice of flux is not solely aesthetic but follows a combinatory logic tied to the customer's overall system—that is, the combination of body, glaze, and grit. A flux that performs optimally in one configuration may not be equally effective in another due to differing chemical interactions between materials. For this reason, multiple solutions, such as F205 and F215, are offered, which can behave differently depending on the glaze used.

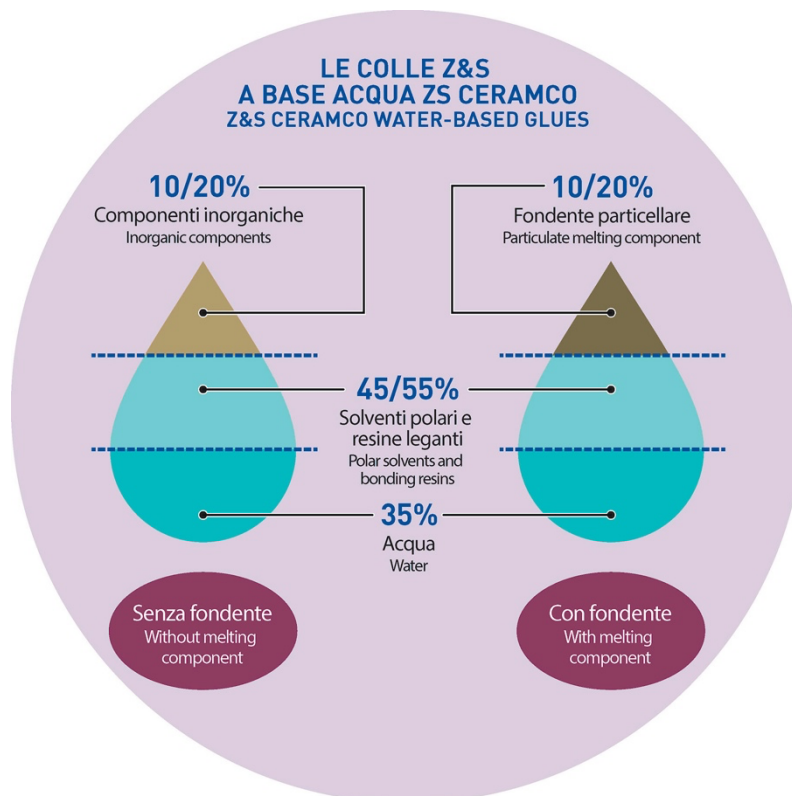
The presence of flux also introduces solid particles into the fluid, creating a significant operational difference compared to glues like Alpha 10. Being free of flux, Alpha 10 does not experience sedimentation and requires minimal maintenance, allowing operators to handle it with ease.



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In glues containing solid particulate, the flux—solid and in nanometric form—tends, even if only slightly, to settle. This introduces an additional layer of operational complexity compared to glues without solids, which users must consider. Proper handling practices are recommended, such as storing the glue in automated systems that keep the material constantly stirred or re-homogenizing the product before production starts, ensuring stability and uniformity. These are minor measures that can now be automated and do not impact normal production operations.



6. Working temperature

Temperature is a critical process variable for water-based glues. While our glues can adapt to a wide range of scenarios, they can currently be grouped into two operational temperature ranges, closely linked to their viscosity and water content:

- Approssimativamente **35°C**: F04, Alpha 10.
- Approssimativamente **45°C**: F05, F205, F215.

Under standard operating conditions, the average working temperature should generally be around 40 °C. This choice has historical roots in specific technical requirements, particularly the need to preserve the machine and its components over time, such as the print heads.

The recommended operational range is typically between 40 °C and 45 °C. Staying within this range helps control water evaporation, which constitutes a significant portion of the formulation. At lower



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temperatures, water evaporates more slowly, while exceeding these limits can lead to excessive vapor production, which may negatively affect the overall printing process.

Product	Working temperature
AQUABOND F04	Approx. 35°C
AQUABOND F05	Approx. 45°C
AQUABOND F205	Approx. 45°C
AQUABOND F215	Approx. 45°C
AQUABOND ALPHA 10	Approx. 35°C

In general, formulations with lower water content reach the desired viscosity more easily and can therefore be used at lower operating temperatures. Conversely, glues with higher water content require higher operating temperatures to achieve the fluidity needed for digital printing.

From our experience, using water-based glues offers an advantageous operational scenario: they provide excellent drying times while allowing work at overall lower temperatures compared to solvent-based solutions, which require higher thermal conditions. This approach helps avoid issues with water repellency or incompatibility with subsequent applications, making the process more stable and flexible within modern ceramic production lines.

7. Intended use: full polished vs. decor

The choice of glue has a direct impact on the type of ceramic product that can be produced, influencing both the final aesthetics and the behavior of the printing process. Within Z&S's range, a clear technical distinction can be made between glues without solid content and those containing a solid component, namely the flux.

Alpha 10, a formulation without solid particles, is characterized by excellent leveling: the glue spreads evenly across the surface, ensuring a uniform film. This makes it particularly suitable for full-surface applications, such as full polished finishes, where the goal is smooth, continuous surfaces free of irregularities.

Glues containing flux, such as F04, F05, and similar formulations, behave similarly but with an added advantage. The suspended solid particles limit the spread of each drop once deposited, keeping the point more stable and defined. This results in high printing precision, making these glues ideal for creating complex details, such as recessed or raised veins, precise geometries, and high-definition graphics.

From a physical standpoint, while the complete scientific explanation is complex, practical experience clearly shows that introducing solid particles in suspension significantly enhances print definition, improving control over the droplet and the final design.

Choosing the most suitable solution for a customer often involves an operational and production compromise. On one hand, Alpha 10 offers simplicity of handling, ideal for large-volume, full-surface production. On the other hand, glues with flux provide greater graphic versatility, enabling more complex and refined aesthetic results, though with a slightly higher level of maintenance.



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8. Certifications (OEM)

Z&S glues are certified and validated by the leading Italian ceramic equipment manufacturers (OEMs). The certification landscape is still evolving: some manufacturers have had established protocols in place for years, while others are in the process of finalizing their official standards. Nevertheless, our glues are already running on industrial machines across all major brands. Rather than providing a static list—which could exclude markets where local certification is not required—the key message is proven compatibility with the technologies currently in use.

In conclusion, the Z&S glue range represents the state of the art in water-based technology. These are not “lab-scale” products, but mature solutions refined over more than 12 years of experience and adapted to real production conditions in the ceramic industry. The breadth of the range is not redundancy but specialization: we provide the right tool—lubricating, with or without flux—to align chemistry with each customer’s machinery, ensuring process stability and high aesthetic quality.

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