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Understanding Flux Chemistry : PCBA Assemblies

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Understanding Flux

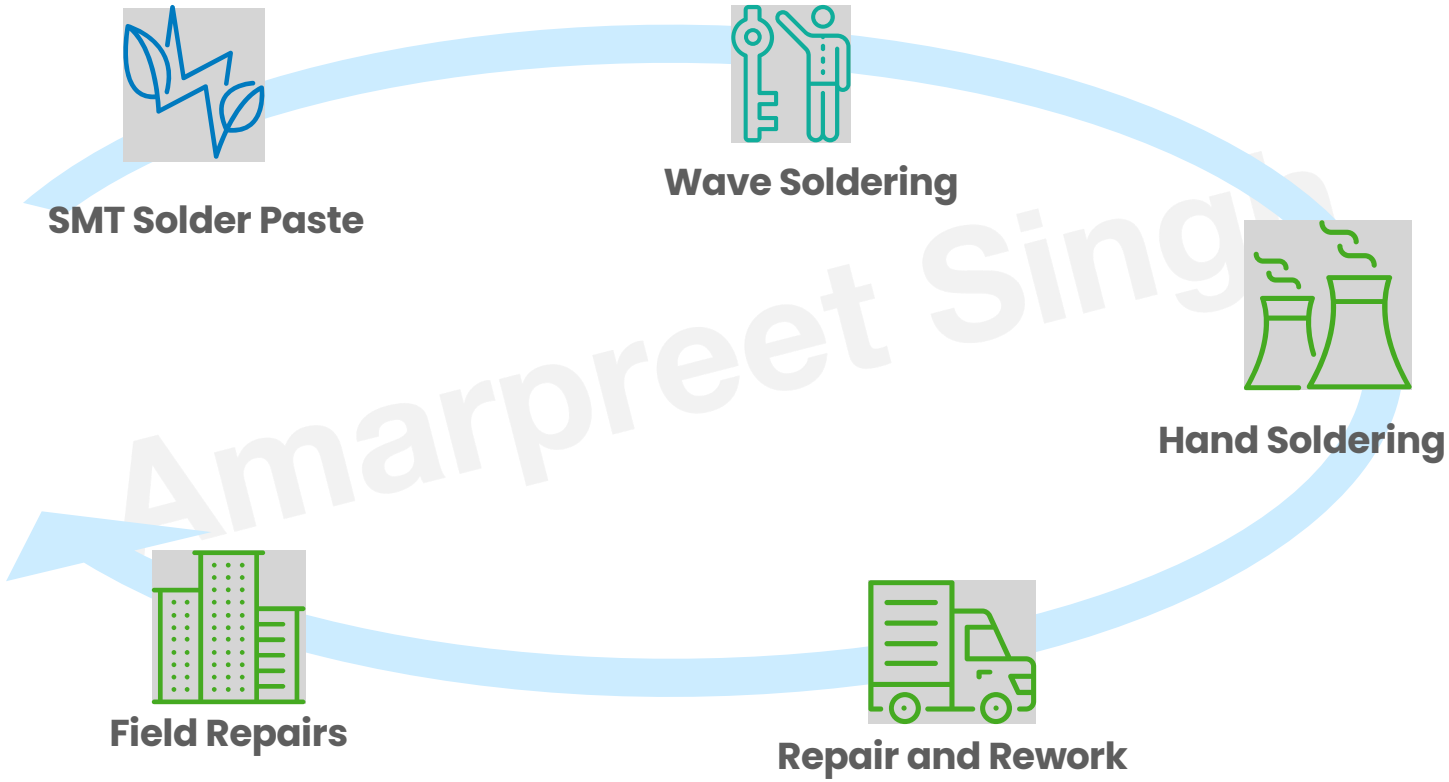
Flux is a chemical used in soldering to clean metal surfaces and help the solder flow smoothly. It removes oxides, promotes the spread of molten solder, and improves adhesion.

Flux comes in forms like paste, liquid, or inside solder wire. When heated, it activates, cleaning the metal and preventing new oxides from forming.

This ensures the solder flows evenly and creates strong, reliable joints by protecting the metal from oxidation during soldering.

Where Used

During the assembly process, flux is applied wherever a solder joint on the PCBA needs to be created or repaired.

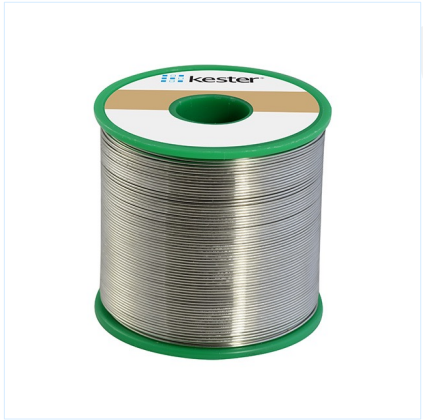


Application Methods

Solder Paste

Wave Soldering Flux

Tacky Flux



Solder Wire

Manual Soldering Flux

Purpose

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Remove Oxides

Flux cleans the surfaces of the metal pads and component leads by removing oxides and other contaminants that form naturally on metals.

Solder Flow

Flux helps molten solder flow more easily across the surfaces to be joined, ensuring that the solder spreads uniformly to create reliable electrical and mechanical connections.

Wetting

It increases the wetting action of the solder, allowing it to adhere better to the metal surfaces, leading to stronger and more consistent solder joints.

Solder Balling

Flux minimizes defects such as solder balling, where solder balls are formed instead of properly bonding to the joints, thereby enhancing the overall quality of the final assembly.

Type of Fluxes

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ROSIN FLUX

Rosin flux, made from pine sap, is a non-corrosive and non-conductive option widely used in soldering. It combines rosin with an activator for better cleaning and soldering.

WATER SOLUBLE FLUX

Water-soluble flux can be easily cleaned with DI water after soldering but requires thorough cleaning to prevent corrosion. It is more aggressive than rosin flux and is used in high-reliability electronics where removing residue is essential..

NO CLEAN FLUX

No-clean flux leaves minimal residue, reducing the need for cleaning. However, cleaning is still recommended to prevent signal issues and circuit malfunctions. It's a popular choice in fast, efficient manufacturing processes.

Flux is chosen based on the product's final application, production volumes, electrical sensitivity, and operating conditions in the field.

Rosin Flux

Definition

Origin: Rosin flux originates from the natural resin of pine trees, specifically from the sap, also known as rosin or colophony. This resin is harvested, purified, and then used as a flux in soldering processes.

Key Characteristics: Non-corrosive, non-conductive, and widely used in traditional soldering.

Composition

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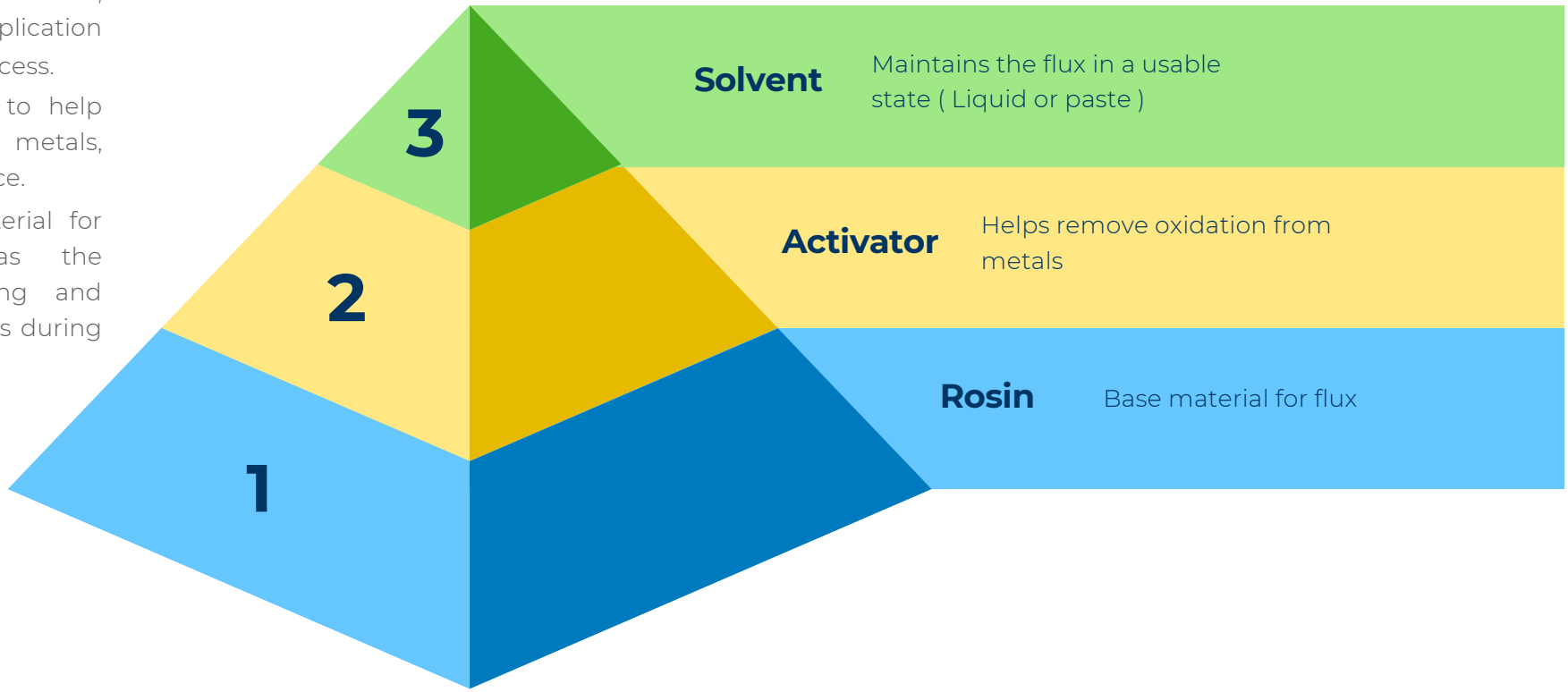
- The rosin flux contains a solvent, which keeps it in a usable form, allowing for easy application during the soldering process.
- An activator is added to help remove oxidation from metals, ensuring a cleaner surface.
- Rosin is the base material for flux, and serves as the foundation for cleaning and preparing metal surfaces during soldering.



Types of Rosin Flux

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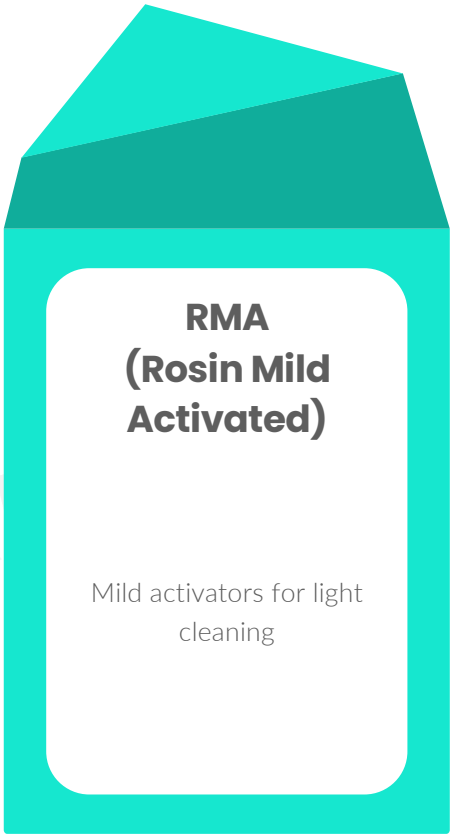

Advantages

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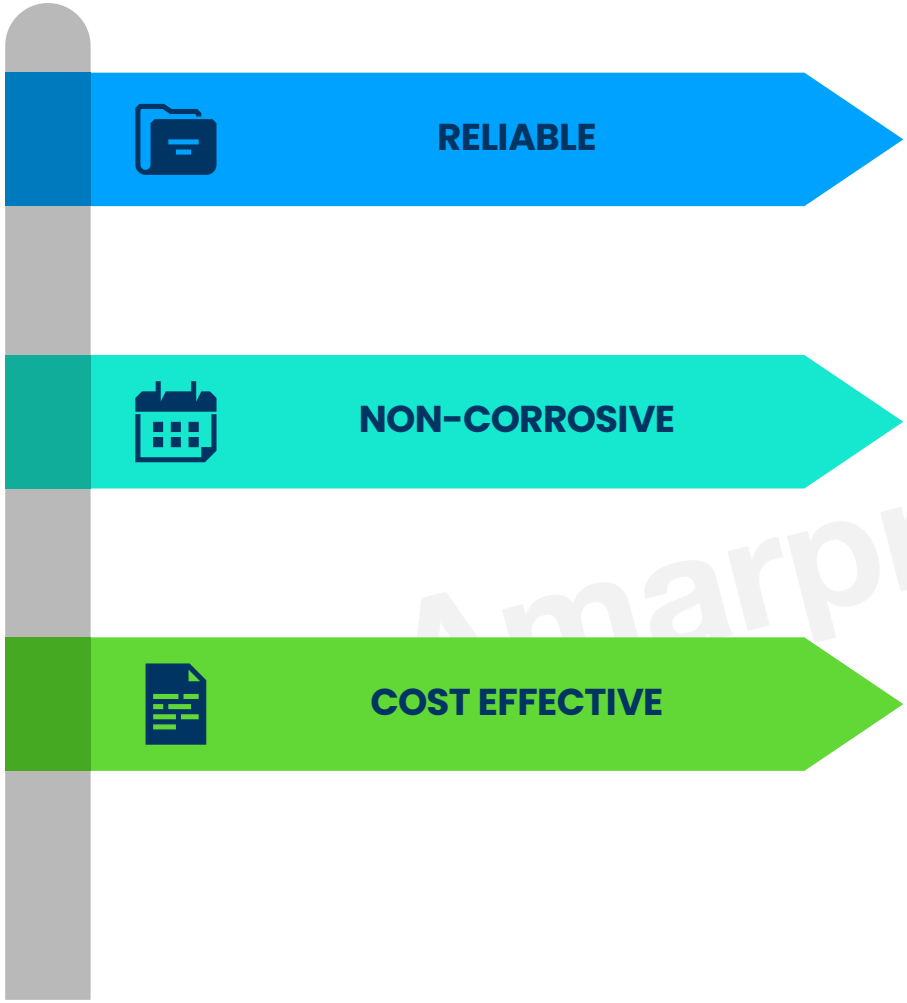

1

Rosin flux has a proven track record of effectiveness across a range of soldering methods, including manual, wave, and reflow soldering, ensuring high-quality joints and consistent performance in diverse electronic assembly applications.

2

The residues left by rosin flux are non-corrosive, making them safe for sensitive electronic components and preventing potential damage over time.

3

Rosin flux is widely available and affordable, making it an economical choice for general-purpose soldering tasks in both industrial and DIY applications.

Dis-Advantages

01 CLEANING REQUIREMENT

While rosin flux is effective, it often leaves behind residues that can be sticky or tacky, necessitating a cleaning process. This can add extra costs to the manufacturing process, in high-reliability sectors. where residue removal is critical.

02 SENSITIVITY TO HUMIDITY

Rosin flux can absorb moisture from the environment, which may compromise its effectiveness during the soldering process. In humid conditions, the flux may become less effective at preventing oxidation, leading to potential solder defects or poor joint quality.

03 LIMITED SHELF LIFE

Rosin flux has a finite shelf life, and its performance can degrade over time, especially if not stored properly. Factors such as temperature, humidity, and exposure to air can negatively impact its effectiveness, which requires careful inventory management in manufacturing settings.

Challenges

- Residue Cleaning: Requires cleaning, especially for RMA and RA types, to avoid interference in high-frequency circuits.
- Environmental Concerns: Traditional rosin fluxes may not be environmentally friendly due to solvent emissions.

Clean Flux

Definition

Water soluble Flux, also known as clean flux is used in PCBA

(Printed Circuit Board Assembly) during the soldering process.

- Requires cleaning after soldering to remove residues.
- Residues may be conductive, corrosive, or harmful to long-term reliability.
- Commonly used in high-reliability applications (e.g., automotive, aerospace, medical devices).

Composition

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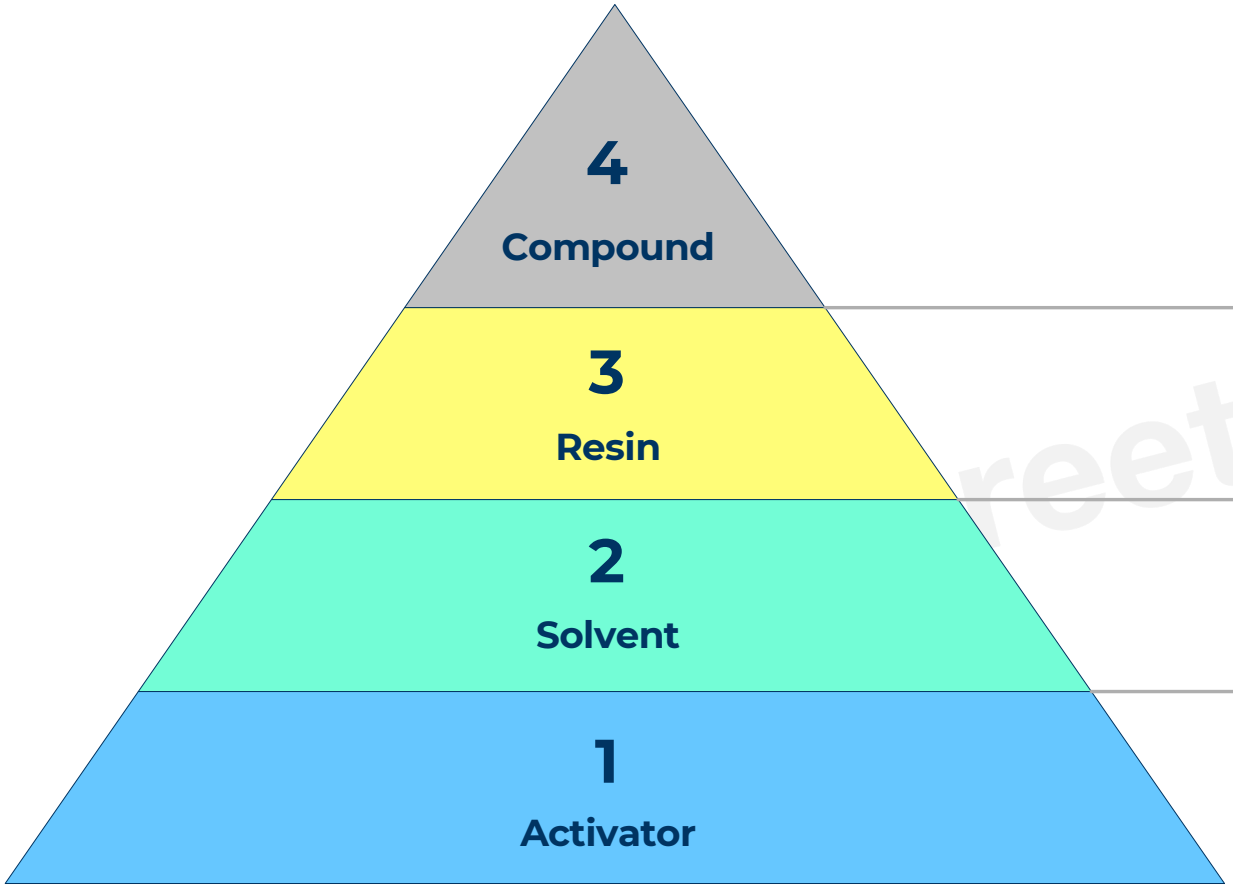


Clean flux often contains organic acids or other water-soluble compounds that make it easier to clean the residues using water-based cleaning processes

Some clean fluxes may contain resin, which acts as a binder to improve the physical properties of the flux during application. These resins may be water-soluble or require specific solvents for cleaning

Solvents help carry the activators and other flux components and evaporate during the soldering process. Common solvents include water or alcohol-based solutions..

These are chemicals, often organic acids or halides, that react with oxides on the metal surfaces, cleaning them and promoting wetting by solder.

The activators are strong and can leave behind corrosive residues, which is why cleaning is necessary.

Advantages

RELIABLE

Clean flux ensures the removal of corrosive or conductive residues after soldering, improving long-term reliability, especially in high-humidity or high-temperature environments where residues can degrade performance.

SUITABLE FOR EXTREME ENVIRONMENTS

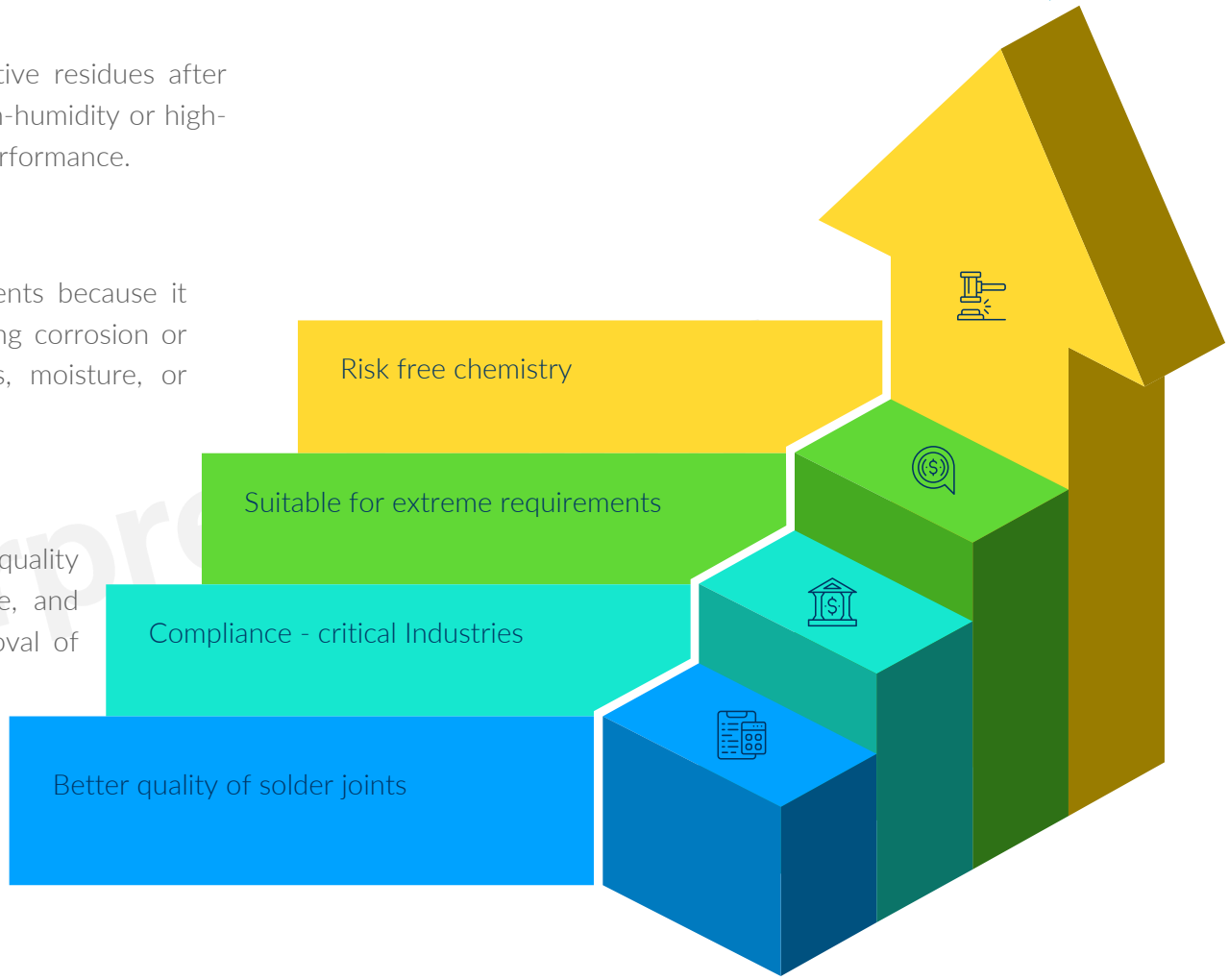
Clean flux is optimal for PCBs used in harsh environments because it ensures that no residues remain after cleaning, preventing corrosion or failure due to stress factors like temperature changes, moisture, or electrical stress.

COMPLIANCE

Clean flux is frequently necessary in industries with strict quality and reliability standards, such as automotive, aerospace, and medical sectors. These industries require complete removal of flux residues to prevent long-term damage to the PCB.

SOLDER JOINT QUALITY

Clean flux generally provides better wetting and stronger solder joints due to its aggressive cleaning action during the soldering process.



Dis-advantages

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1 **ADDITIONAL PROCESS**

After soldering, the residues from clean flux must be thoroughly removed. This requires a post-soldering cleaning step, typically involving water or solvent cleaning, which increases both process complexity and time.

2 **INCREASED COST**

The need for specialized cleaning equipment and cleaning agents adds to the overall cost of the manufacturing process. Facilities must invest in cleaning stations, and the cleaning agents and solvents add ongoing operational costs.

3 **ENVIRONMENTAL IMPACT**

Water-soluble fluxes may require large amounts of water for cleaning, and the disposal of the cleaning solutions needs to be carefully managed to meet environmental regulations

Dis-advantages

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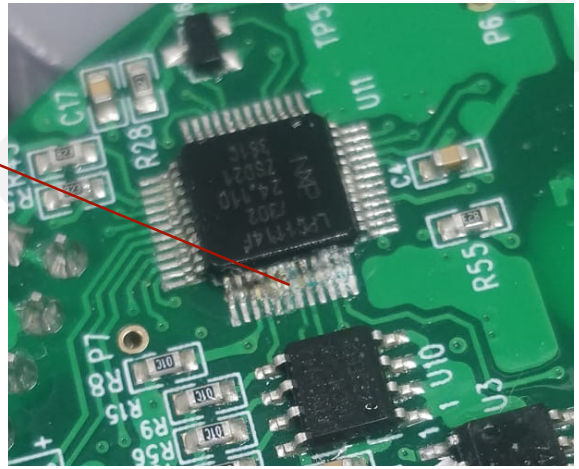
4 **POTENTIAL FAILURES**

If the cleaning process is not done correctly or thoroughly, residues may remain, causing potential issues like corrosion or decreased electrical insulation over time.

Field Failures : Water soluble flux residue, if not cleaned properly can cause electrical failures in the field.



Verification

- The successful removal of clean flux residues is essential in high-reliability applications, as even small amounts of residue can compromise the long-term performance of a PCB.

- This testing process ensures that potentially harmful ionic residues—known to cause issues like corrosion, electrical leakage, or complete failure—are thoroughly eliminated, thereby safeguarding the functionality and durability of the assembly.

Verification

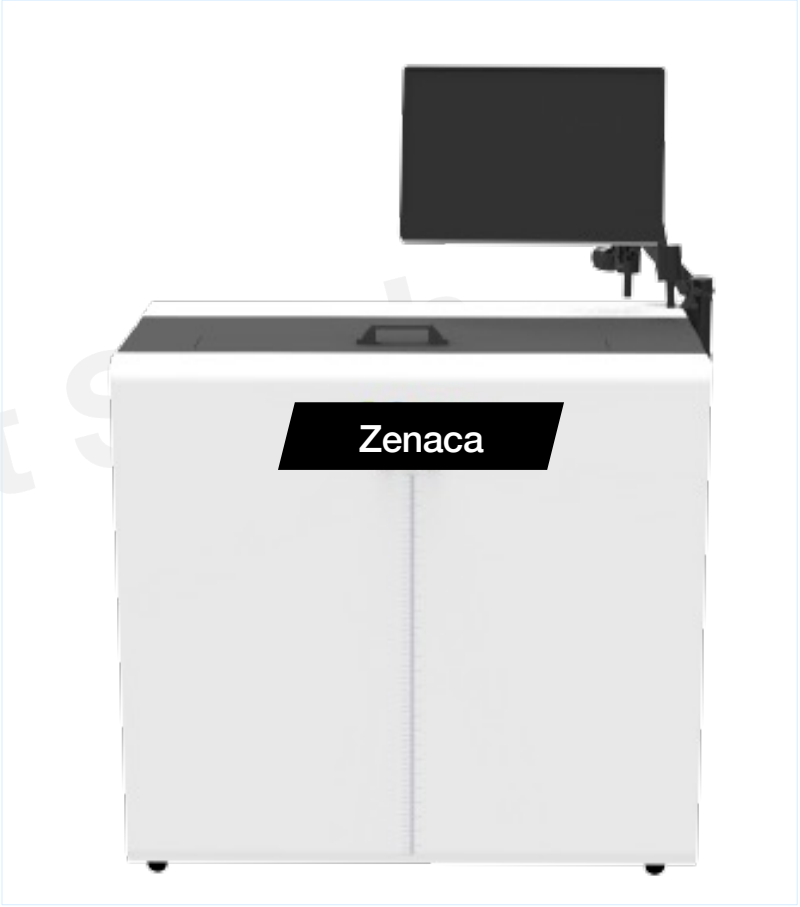
- Regular testing verifies that the cleaning process meets stringent reliability standards required in industries like aerospace, automotive, and medical devices.

- It is recommended to clean the flux within two hours of the board coming out of wave soldering, SMT or other soldering process. A delay in cleaning process, can make the flux hard thus difficult to remove during the cleaning process.

ROSE Tester

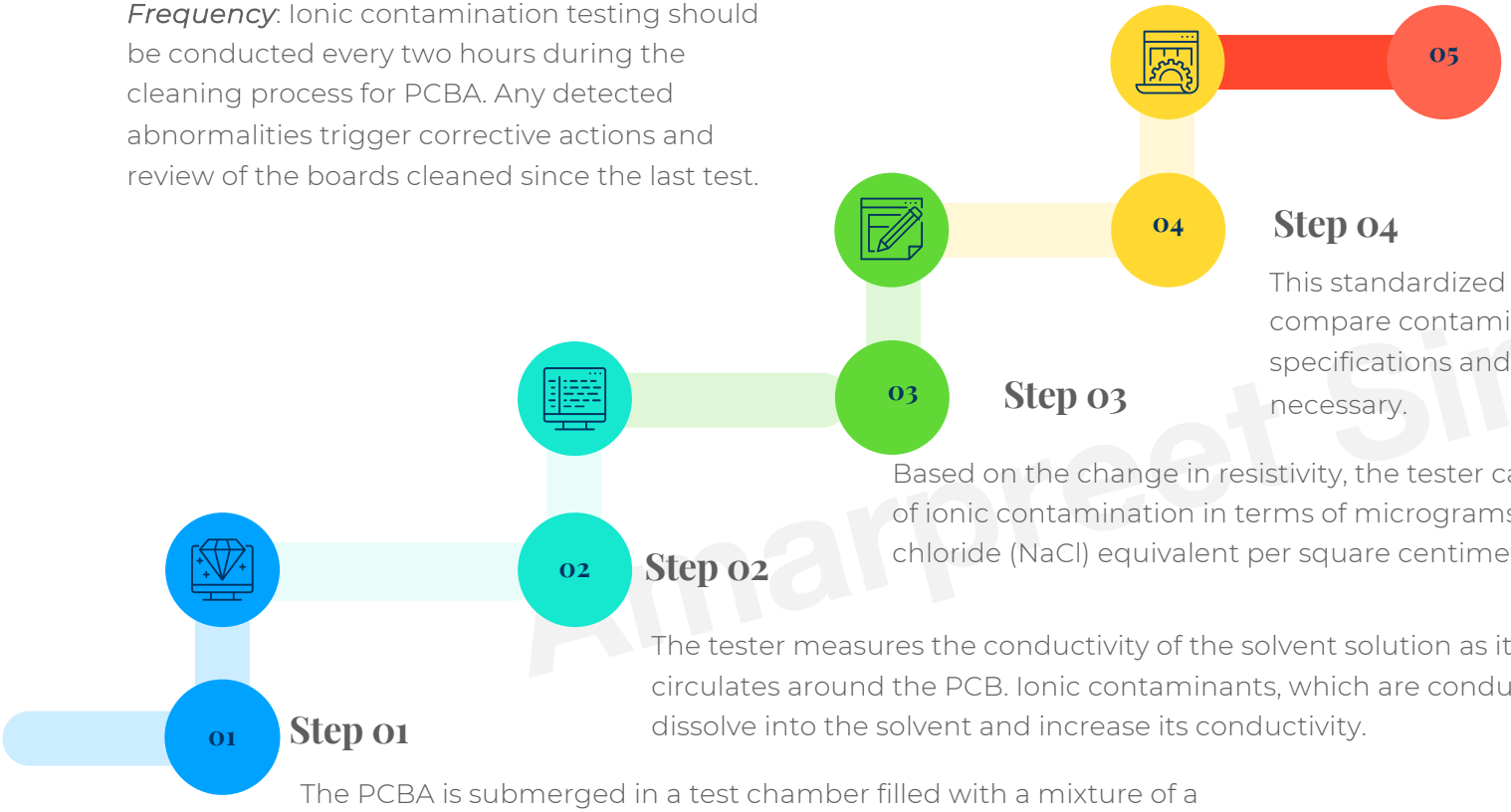
An Ionic Contamination Tester is a tester used to measure the amount of ionic contamination left on a PCBA after the cleaning process.

This tester is also known as ROSE tester (Resistivity Of Solvent Extract) tester.



How ROSE Tester Works ?

Frequency: Ionic contamination testing should be conducted every two hours during the cleaning process for PCBA. Any detected abnormalities trigger corrective actions and review of the boards cleaned since the last test.



01 **Step 01**

The PCBA is submerged in a test chamber filled with a mixture of a solvent (usually IPA). This solvent dissolves any ionic residues present on the PCB, such as salts, acids, or flux residues.

02 **Step 02**

The tester measures the conductivity of the solvent solution as it circulates around the PCB. Ionic contaminants, which are conductive, dissolve into the solvent and increase its conductivity.

03 **Step 03**

Based on the change in resistivity, the tester calculates the level of ionic contamination in terms of micrograms of sodium chloride (NaCl) equivalent per square centimeter (µg NaCl/cm²).

04 **Step 04**

This standardized unit allows manufacturers to compare contamination levels to industry specifications and determine if further cleaning is necessary.

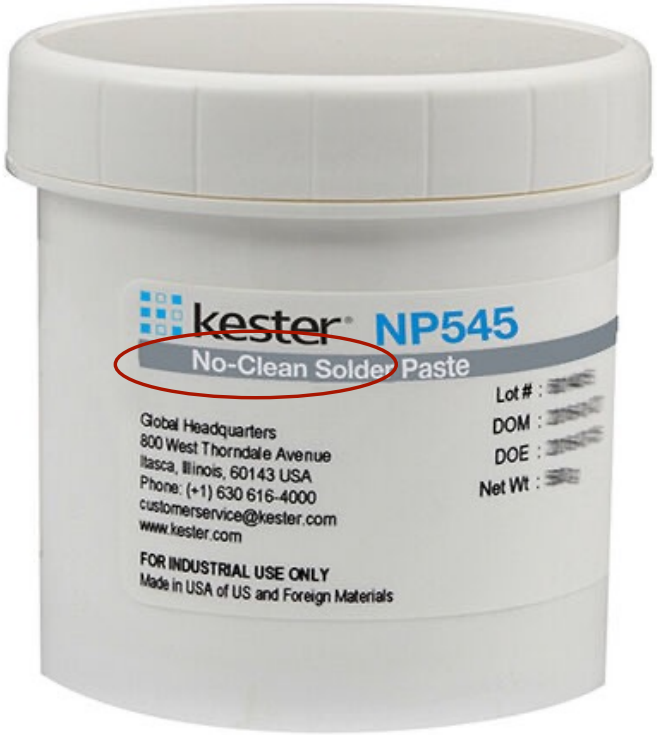
05 **Step 05**

If the contamination levels fall below the specified threshold (typically set by industry standards like IPC-J-STD-001), the cleaning process is deemed effective.

No-Clean Flux

Definition

No-Clean Flux used on PCBA (Printed Circuit Board Assembly) during SMT and wave soldering processes is a type of flux that leaves behind minimal, non-conductive, and non-corrosive residues after soldering.



Definition

- The key characteristic of no-clean flux is that it does not require post-soldering cleaning, making it ideal for high-volume production environments where speed and cost-efficiency are critical and products are not exposed to aggressive environments in the field.

- No clean flux is commonly used in consumer, low end industrial and similar products.

Composition

No-clean fluxes are formulated with materials that are less active compared to clean fluxes, ensuring that the residues left after soldering do not need to be removed. Components of a no clean flux are -

- Activator
- Resin
- Solvent
- Additive

Composition

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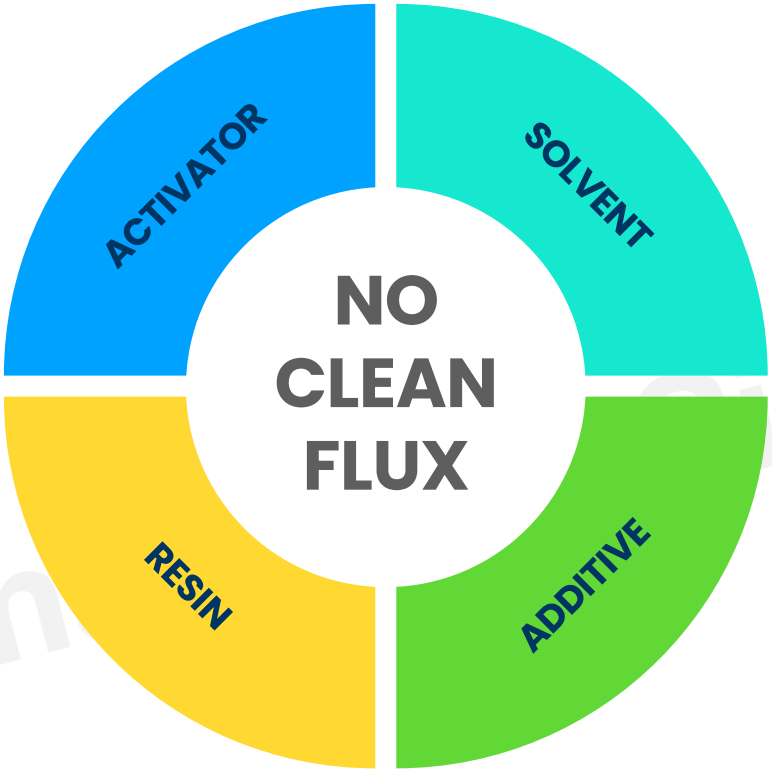
- These are weak organic acids that help remove oxidation from the surfaces being soldered but are not as aggressive as those found in clean fluxes.
- Common activators include adipic acid, citric acid, or succinic acid



- Solvents like alcohols (such as isopropyl alcohol) or other volatile liquids are used to dissolve and transport the activators and resins, enabling easy application of the flux.
- During the soldering process, these solvents evaporate, leaving behind a harmless residue.

- No-clean flux generally includes natural or synthetic resins (such as rosin), which encase the flux residue to keep it non-conductive and non-corrosive.
- These resins create a protective layer over the residue, rendering it harmless after the soldering process.

- Some no-clean fluxes include additives to enhance specific properties like heat resistance, stability during storage, or better wetting capabilities.

Types of No Clean Flux

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Rosin Based No Clean Flux

Contains natural or synthetic rosin (a type of resin) that leaves behind a minimal, benign residue.

Low-Solids No-Clean Flux

These fluxes contain a minimal amount of solids (activators and resins) to reduce the quantity of residue left behind after soldering.

Alcohol-Based No-Clean Flux

Uses an alcohol solvent to evaporate quickly during soldering, reducing the likelihood of excessive residue.

Advantages

REDUCED PROCESS

The primary advantage of no-clean flux is that it eliminates the need for a post-soldering cleaning process. The residues are inert and non-conductive, so they do not need to be removed, which simplifies the process and reduces manufacturing time.

COST AVOIDANCE

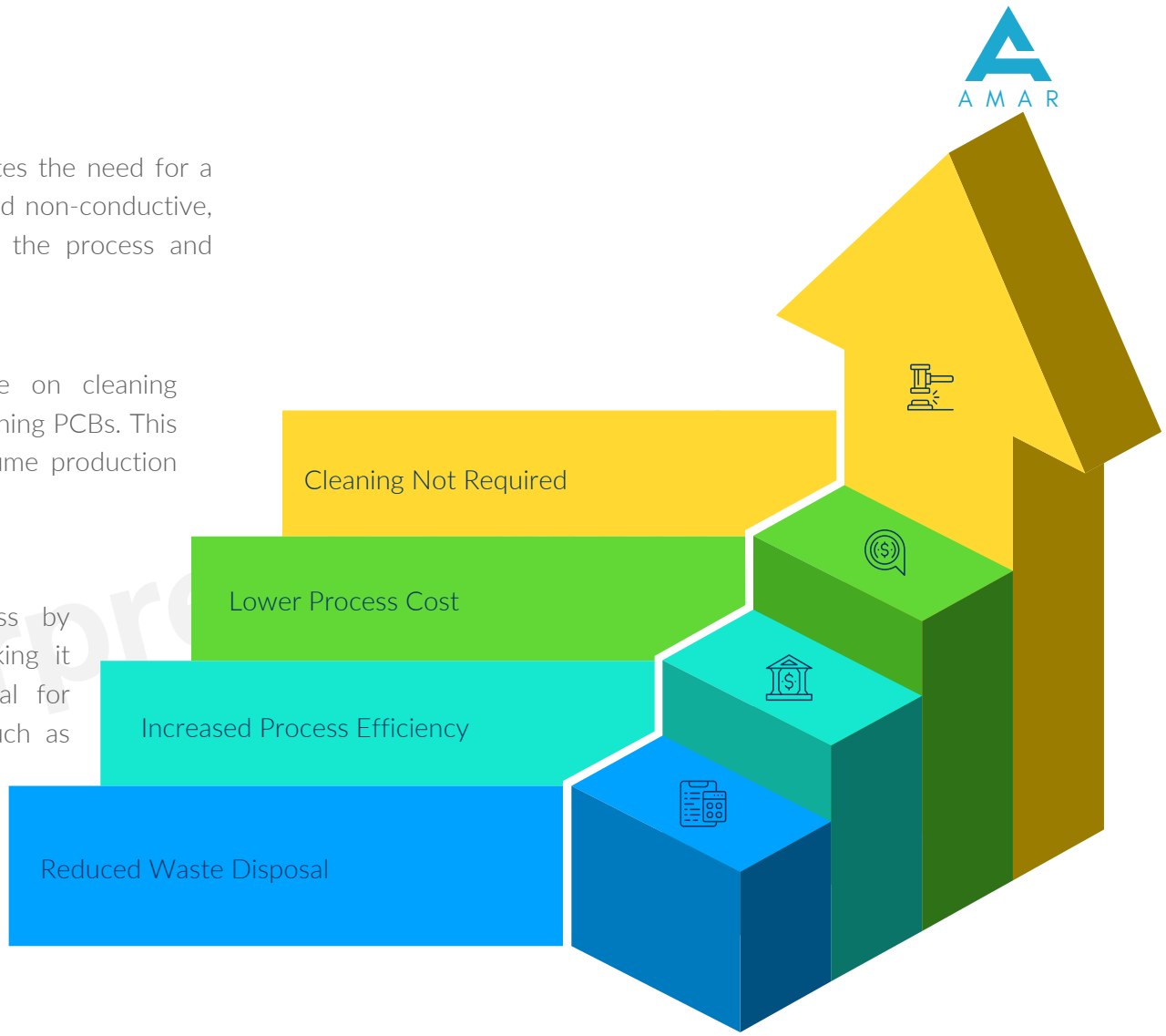
Since there is no cleaning step, manufacturers save on cleaning equipment, cleaning agents, and the labor involved in cleaning PCBs. This makes it a cost-effective solution, especially in high-volume production environments.

PROCESS SPEED

No-clean fluxes streamline the manufacturing process by eliminating the need for additional cleaning steps, making it faster and more efficient. This is particularly beneficial for industries that prioritize speed and high throughput, such as consumer electronics.

ENVIRONMENTAL FRIENDLY

No-clean flux minimizes the environmental impact since it reduces the use of cleaning solvents, chemicals, and water. There is no need for waste disposal of contaminated cleaning fluids, making it a more environmentally friendly option.



Advantages

RELIABILITY

No-clean flux ensures dependable operation in controlled environments, where factors like temperature and humidity are stable. It leaves behind residues that are generally inert, minimizing risks such as corrosion or electrical failures.

LOW RISK UNDER CONTROLLED ENVIRONMENT

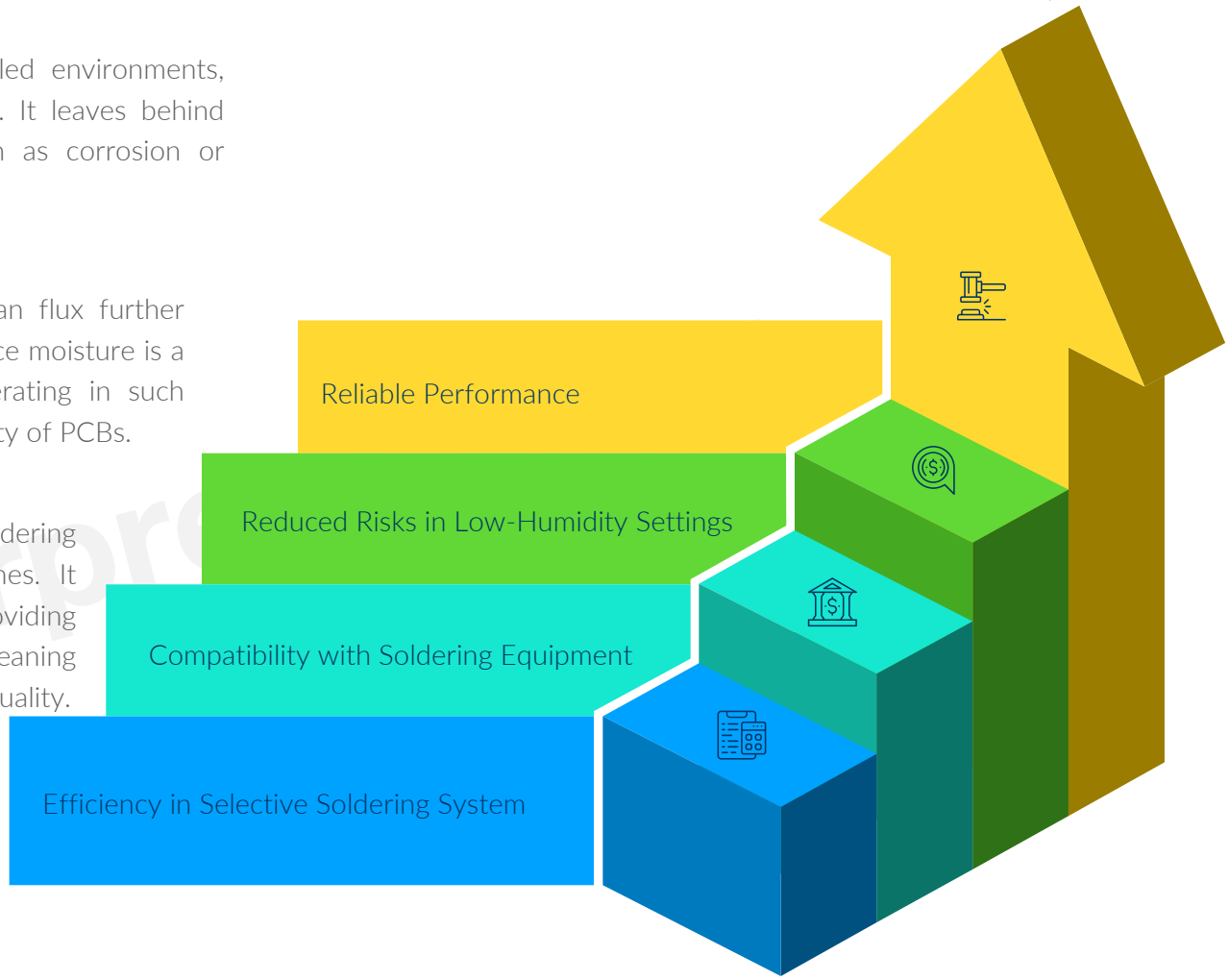
In environments with consistently low humidity, no-clean flux further reduces the chances of issues related to flux residues. Since moisture is a key factor that can cause residue-related failures, operating in such conditions enhances the long-term stability and functionality of PCBs.

COMPATIBILITY

No-clean flux integrates smoothly with modern soldering systems like reflow ovens and wave soldering machines. It performs well within these advanced technologies, providing optimal soldering results without requiring additional cleaning steps, helping to streamline production while maintaining quality.

SELECTIVE SOLDERING

No-clean flux is also highly effective in selective soldering processes, which demand precision. It works without disrupting machine performance or causing residue buildup, allowing for high-quality solder joints.



Dis-advantages

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1 RESIDUE CONCERNS

While the residues left by no-clean flux are non-conductive, they can lead to cosmetic imperfections or potentially weaken the mechanical integrity of specific components over time. In critical, high-reliability sectors such as aerospace, medical, and automotive industries, even minimal residue can be deemed unacceptable due to concerns about long-term reliability.

2 LIMITATION UNDER HARSH CONDITIONS

If the PCBA will be exposed to harsh environments (e.g., high humidity, corrosive atmospheres, or extreme temperature fluctuations), the residues left by no-clean flux can absorb moisture over time, potentially leading to corrosion or failure of the assembly.

3 CRITICAL PROCESS CONTROLS

If the soldering process is not carefully controlled, the residues left by no-clean flux can result in poor solder joints, bridging, or other defects. If the No clean Flux is not fully activated during the soldering process, it can cause reliability issues in the field.

Dis-advantages

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4 **REDUCED SURFACE RESISTANCE**

No-clean flux residues can reduce the surface insulation resistance (SIR) of a PCB. In circuits with high voltage or fine pitch components, even low levels of contamination can lead to leakage currents or shorts.

5 **INSPECTION CHALLENGES**

It can be difficult to visually inspect the quality of no-clean solder joints because the residues can obscure defects like cracks or voids, making it challenging to assess joint integrity without more advanced techniques like X-ray inspection.

6 **CONFORMAL COATING ADHESION ISSUES**

In applications where a conformal coating is applied after soldering, the presence of no-clean flux residues can interfere with the adhesion of the coating, leading to delamination or poor coverage.

Recommendations

No-clean flux is typically used in applications where -

- ✓ High production volume and cost efficiency are priorities.
- ✓ The PCBA will operate in controlled environments with low exposure to moisture, contaminants, or extreme temperatures.
- ✓ Consumer electronics or industrial products that are less sensitive to long-term reliability concerns are involved.
- ✓ Cleaning infrastructure is limited or not cost-effective, such as in small-scale production or repair environments.

Q & A

Q&A

Question 1. What is the difference between clean flux and no-clean flux?

Answer 1 : Clean flux requires a cleaning process after soldering to remove flux residues that may be harmful, such as causing corrosion or electrical leakage. No-clean flux, on the other hand, leaves behind residues that are designed to be non-conductive and non-corrosive, making post-soldering cleaning unnecessary for most applications.

Q&A

Question 2. Why is clean flux used in high-reliability applications?

Answer 2 : Clean flux is used in high-reliability applications because it ensures that no harmful residues are left on the PCB. This is critical in environments that experience temperature fluctuations, moisture, or electrical stress, as even minor residues can lead to corrosion, electrical failure, or reduced long-term reliability.

Q&A

Question 3. What are some common industries where clean flux is required?

Answer 3 : Clean flux is commonly required in industries such as aerospace, medical, and automotive, where the reliability and safety of the PCB are crucial. These industries often demand the complete removal of any flux residues to prevent long-term damage to the PCBA's.

Q&A

Question 4. What are the advantages of using no-clean flux in controlled environments?

Answer 4 : In controlled, low-humidity environments, no-clean flux residues do not typically cause reliability issues, making it a practical choice for many consumer and industrial applications. It reduces the need for a post-soldering cleaning step, which lowers costs and simplifies the manufacturing process.

Q&A

Question 5. Can no-clean flux residues affect the appearance or reliability of PCBs over time?

Answer 5 : Yes, while no-clean flux residues are non-conductive, they can sometimes cause cosmetic issues or impact the mechanical strength of certain components over time. This is particularly concerning in high-reliability applications where long-term performance is critical.

Q&A

Question 6. . What is ionic contamination testing, and why is it important?

Answer 6 : Ionic contamination testing measures the effectiveness of removing harmful ionic residues from clean flux. These residues can lead to corrosion, electrical leakage, or failure. The test ensures that any residues that remain after soldering do not pose a risk to the PCB's long-term reliability, especially in critical applications.

Q&A

Question 7. How often should ionic contamination testing be conducted during PCB cleaning?

Answer 7 : It is recommended to perform ionic contamination testing every two hours while the PCB cleaning process is running. Any abnormalities detected during testing should trigger corrective actions and prompt review of the boards cleaned since the previous test.

Q&A

Question 8. . What solvents are typically used in no-clean flux, and what role do they play?

Answer 8 : Solvents such as isopropyl alcohol or other volatile liquids are used in no-clean flux to dissolve and carry activators and resins, allowing easy application. These solvents evaporate during the soldering process, leaving behind benign, non-harmful residues that do not require cleaning.

Q&A

Question 9. Are there any challenges or limitations associated with using no-clean flux in high-reliability applications?

Answer 9 : Yes, in high-reliability applications like aerospace or medical electronics, even small amounts of residue may be unacceptable due to concerns about long-term reliability. The residues, while non-conductive, can sometimes cause issues such as weakening the mechanical strength of certain components or creating cosmetic defects over time, which may not be suitable for these critical industries.

Q&A

Question 10. How does the choice between clean and no-clean flux impact the overall cost and efficiency of the manufacturing process?

Answer 10 : Choosing no-clean flux can reduce the overall cost and increase the efficiency of the manufacturing process. Clean flux, while potentially adding extra steps and costs for cleaning, may be necessary for applications requiring the highest levels of reliability.

The decision depends on the specific requirements of the application and the trade-off between cost and long-term reliability.

Do you have more questions on topic ?

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Thank You