Plural Component Materials and Proportioning Concept and Theory
Material Information

What are plural component materials?

Material suppliers produce, package, and deliver plural component materials to the work site as two or more different component chemicals.

The chemical components must be mixed together in a specified ratio, at the work site, for the chemicals to become a usable material.

After mixing, the material is applied by spraying, dispensing, or extruding.
What happens when the component chemicals are mixed?

A chemical reaction begins spontaneously as soon as the component chemicals are mixed. The component chemicals are transformed into a usable material in a process called *Curing*, *Cross linking* or *Polymerization*. The reaction cannot be stopped or reversed. The material increases in viscosity as the reaction continues, and produces heat as a byproduct. *Exothermic* reactions produce heat as a by-product.

After mixing, the material will provide *Good Application Characteristics*. The period of time that the material provides good application characteristics is called *Working Pot Life*. Working pot life is also known as *Work Time* when working with sealants and adhesives, or *Spray Life* when working with coatings. Working pot life, spray life, and work time are different words used to describe the same idea.

Working pot life ends when the material stops providing good application characteristics. As viscosity increases, finish quality will no longer be acceptable for coatings, sealants will not seal properly, and adhesives will not bond properly. The material is no longer usable and should be purged from the equipment before it hardens.

Viscosity increases until the material hardens. The period of time that starts when the components are mixed and ends when the material hardens is called *Pot Life*. If material hardens in the equipment, the equipment will be ruined. Flush the material from the equipment at the end of working pot life to prevent damage.
Progress Check

After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

Match the terms with the definitions below.

a. Viscosity
b. Plural Component
c. Pot Life
d. Chemical Reaction
e. Spray Life
f. Work time
g. Exothermic
h. Spontaneous
i. Working Pot Life

___1. A chemical reaction that has heat as a by-product.
___2. Increases as the chemical reaction proceeds.
___3. A chemical reaction that begins immediately after the component chemicals are mixed together.
___4. Materials that are produced, packaged, and delivered to the work site as two or more component materials.
___5. Once it starts, it cannot be stopped or reversed.
___6. Starts when the chemicals are mixed and ends when the material hardens.
___7. Begins when chemicals are mixed and ends when the material no longer produces acceptable application characteristics.
___8. Begins when chemicals are mixed and ends when a coating no longer produces an acceptable finish.
___9. Begins when chemicals are mixed and ends when an adhesive no longer bonds properly.
Progress Check Answers

1. G. Exothermic
2. A. Viscosity
3. H. Spontaneous
4. B. Plural Component
5. D. Chemical Reaction
6. C. Pot Life
7. I. Working Pot Life
8. E. Spray Life
9. F. Work Time
What are the functions of the component materials?

In a two-component material we refer to the component chemicals as “Component A” and “Component B”.

Component A is the Base Material. It gives the material its desired properties. Example: Component A is the color in a plural component paint.

Component B is the Catalyst. It does the following:

- Starts the reaction
- Controls the rate of the reaction
- Promotes curing, cross-linking, or polymerization
**What is mix ratio?**

- *Mix Ratio* is the ratio of Component A to Component B that yields the best characteristics of the end product.
- Mix ratio is specified by the material supplier as a function of weight and/or volume.
- The material supplier will specify the mix ratio and a margin of error called *Ratio Tolerance*.
- Ratio tolerance tells you how far off the prescribed mix ratio you can be before you are off-ratio.
- Mix ratio is the most critical factor that determines the physical properties of the end product.
- Too much catalyst may cause problems.
- Too little catalyst may cause different problems.
- Mix ratio affects pot life.
- Off-ratio materials may not cure properly.
- Applying heat will often shorten pot life or speed curing.

![Graph showing the relationship between Pot Life and Temperature. The graph indicates that heat increases the rate of reaction, reducing the working pot life.](image)

Heat increases the rate of reaction, reducing the working pot life.
How is mix ratio measured?

Graco plural component equipment proportions chemical components by volume. If the material supplier provides the mix ratio by weight, the procedure below can be used to convert it to a volumetric mix ratio.

**Weight to Volumetric Mix Ratio**

\[
\text{Volumetric Mix Ratio} = \frac{\text{Weight A}}{\text{Weight B}} \times \frac{\text{Weight/Volume B}}{\text{Weight/Volume A}} = \frac{\text{Volume A}}{\text{Volume B}}
\]

Note: The weight/volume of A and B must be expressed in the same units.

Example: You are given a weight mix ratio of 16:1 (A:B). You are also given:

A = 10 lb/gal  
B = 8.5 lb/gal

We can now write the equation as:

\[
\text{Weight Mix Ratio} = \frac{16}{1} \times \frac{8.5 \text{ lb/gal}}{10 \text{ lb/gal}} = 13.6:1
\]
What are the different names for component chemicals?

Some plural component materials can use three chemicals (3k): a base, a catalyst, and an accelerator.

- Learn and use the customer's terms for each component
- The plural component material supplier educates the customer on terminology
- Follow the supplier's lead
### Types of Plural Component Materials and Their Uses

#### Epoxies

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#### Polyurethanes

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Polyster, Catalyzed Lacquers, Polysulphides, and Silicones are other plural component materials that have applications as decorative coatings, protective coatings, foams, sealants, and adhesives.
What are the advantages of using plural component materials?

Excellent material characteristics when properly blended:

- Durability
- Abrasion Resistance
- Chemical Resistance
- Flexibility
- Promotes Adhesion
- Appearance

Environmentally Friendly:

- Low VOC (Volatile Organic Compound) emissions
- Lower energy consumption while curing, many materials do not require heat to cure
- Mixed cure material can be disposed of as non-hazardous waste

Cost Effective:

- Ovens may not be required
- Cure quickly, reducing time on assembly line
- May not require stainless steel equipment
What are the limitations of using plural component materials?

Coating cost is high:

- Plural component materials are typically more expensive than single component materials

Incorrect mix ratios result in costly failures:

- Material characteristics do not develop properly
- Lost production and profits due to need to:
  - Strip the material off the product and re-apply
  - Dispose of scrapped products
- Warranty costs
  - Rework
  - Scrap
- Many units may be produced because the off-ratio condition may not be noticeable on production line
- Production systems are required to monitor and control the mix ratio to assure quality finished products

Exceeding pot life causes costly problems:

- Equipment fails or becomes clogged when mixed material exceed pot life before equipment is cleaned. You must clean, replace, or repair clogged equipment.
- Equipment must be cleaned before pot life is exceeded, generating wastes that are expensive to properly dispose of.
Progress Check

After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

1. Match the terms below.
   a. Component “A”
   b. Component “B”
   c. Type of plural component material
   d. Use of plural component material

   ____1. Accelerator
   ____2. Activator
   ____3. Adhesive
   ____4. Base
   ____5. Catalyst
   ____6. Catalyzed Lacquer
   ____7. Decorative Coating
   ____8. Epoxy
   ____9. Foam
   ____10. Hardener
   ____11. Isocyanate
   ____12. Lacquer
   ____13. Polyester
   ____14. Polyol
   ____15. Polysulphide
   ____16. Polyurethane
   ____17. Prepolymer
   ____18. Promoter
   ____19. Protective Coating
   ____20. Resin
   ____21. Sealant
2. Identify the statements below as an advantage or a limitation.

A. Advantage
B. Limitation

____ Plural component materials have excellent physical properties when properly blended and applied.
____ Pot life limits the time mixed material can safely remain in application equipment.
____ Plural component materials may not require heat to cure.
____ Off-ratio blending may result in costly failures.
____ Plural component material usage is cost competitive compared to other compliant coatings.
____ Many plural component materials do not require stainless steel equipment.
____ Production systems are required that can monitor and control the mix ratio to assure a quality finished product.
Progress Check Answers

1. Match the terms below.
   1. B. Component “B”
   2. B. Component “B”
   3. D. Use of plural component material
   4. A. Component “A”
   5. B. Component “B”
   6. C. Type of plural component material
   7. D. Use of plural component material
   8. C. Type of plural component material
   9. D. Use of plural component material
   10. B. Component “B”
   11. B. Component “B”
   12. A. Component “A”
   13. C. Type of plural component material
   14. A. Component “A”
   15. C. Type of plural component material
   16. C. Type of plural component material
   17. A. Component “A”
   18. B. Component “B”
   19. D. Use of plural component material
   20. A. Component “A”
   21. D. Use of plural component material

2. Identify the statements below as an advantage or limitation.
   A Advantage
   B Limitation
   A Advantage
   B Limitation
   A Advantage
   A Advantage
   B Limitation
Product Information

What is isocyanate and its relationship to fluid handling equipment?

Isocyanate is a plural component chemical that is often used as a catalyst. Isocyanate is sensitive to moisture, even the light amount of moisture in the air. Moisture from the air will react with the isocyanate and create a plastic film over the top of the material in the container. This plastic film can cause a variety of fluid handling equipment problems. To prevent the plastic film from developing, a dry air blanket or an inert gas (Nitrogen) is supplied over the open container of isocyanate isolating the material from the moisture in the air. This is done using either a desiccant dryer (uses chemical crystals to dry the air supply to the container), or a nitrogen bottle supply.

![Nitrogen Supply](image1.png) ![Desiccant Dryer](image2.png)

Equipment failure will happen when isocyanate weeps past the throat packing in a piston pump. This weepage combines with the moisture in the air and forms hard crystals. These crystals act as an abrasive to the throat seals in the pump, causing the pump to fail prematurely. Graco Iso Pump Oil (IPO) is used in the wet cup of the pump to prevent the crystallization from occurring. The oil isolates the weepage from the moisture in the air.

Moisture in the air can pass through fluid hoses. If the incorrect hose is selected for isocyanate, the material can cure in the hose and eventually cause a hose rupture and spillage problem. Polytetrafluoroethylene (PTFE) and Polyolefin (Moisture Lok™) hoses will not absorb moisture easily and are recommended for isocyanate.

Special safety considerations must be used when working with isocyanate materials. Be sure to refer to the material suppliers safety recommendations.
How are plural components proportioned?

How Manual Proportioning Works ("Hot Potting", "Batch Mixing")

The operator measures out the correct amount of each component into a container and mixes
the materials until they are blended completely. The mixed chemical is then applied by the
operator prior the end of the work time for the material.
How Mechanical Proportioning Works

Two or more pumps or pressure tanks supply a simultaneous flow of fluid to the proportioner. Mechanical proportioners use two or more displacement pumps to measure the component chemicals. The pump strokes are synchronized by a mechanical connection. As the pumps operate, they meter out component chemicals in ratios determined by the displacement of the pumps. Fluid is directed from the pumps to a mixing mechanism, then applied to the end product.
How Electronic Mixing Works

The fluid supplies deliver the chemicals under pressure to the fluid manifold. On the manifold are all the components to meter and mix the chemicals on demand. The system uses special computer software and other electronics to control the flow of each component material. This system allows proportioning of the materials very accurately, shuts down the system automatically if a problem develops, and can output material usage reports.
What are the advantages and limitations of manually proportioning plural component materials?

**Advantages**
- No expensive equipment.
- Some ratio tolerances are not critical; therefore no accurate measuring system is needed.
- May generate less waste in very low usage applications.

**Limitations**
- Container disposal is a problem. It may be difficult to clean the containers, resulting in the need to dispose of them.
- Unused material disposal is expensive. Material must be mixed in batches before application begins, which usually results in more waste. Leftover material cannot be saved.
- High percentage of labor dollars are spent preparing to paint.
- “Quality of work life” due to handling and cleaning toxic or unpleasant component materials.
- Safety issues related to handling toxic chemicals.
- Maintaining mix ratio within specified tolerances may be difficult.
- Some materials are physically difficult to mix properly.
- Errors when mixing the components (i.e., did you forget to add catalyst or did you add it twice?)
What are the advantages and limitations of using mechanical proportioners to mix plural component materials?

Advantages
- Mechanical proportioners efficiently handle large volumes of plural component materials.
- They are generally reliable.
- Mechanical proportioners can pump, mix, and apply materials with short pot lives very quickly.
- They work on demand, mixing only what is needed.
- The work environment is cleaner and safer when compared to manual mixing.
- They can be installed in hazardous areas without major modifications.

Limitations
- Mechanical equipment requires regular maintenance and repairs.
- Mix ratio is affected as mechanical parts wear.
- Operator error can result in the wrong mix ratio or material left in equipment past its pot life.
- Limited ratio range.
- Chemical breakdown of the material called shearing is caused by mechanical components.
- Mechanical proportioners can cavitate, resulting in an off-ratio condition.
- Cavitation occurs when one or more of the supply pumps do not fully fill with fluid.
- No inherent ratio verification or process data capability.
- Generates material waste when changing colors.
- Slow and complex to change colors.
What are the advantages and limitations of using electronic proportioners to mix plural component materials?

**Advantages**
- Accurately maintains desired ratio, self-correcting.
- Meters and mixes on demand only what is needed to complete the job.
- Designed to monitor the process effectively.
- Provides material usage reports.
- Cleaner, safer work environment.
- Handles a wide range of ratios.
- Dispenses multiple ratios.
- Automatically self-purges if pot life is exceeded.
- Simpler to maintain than mechanical proportioners.
- Color change and purging is faster and generates less waste.

**Limitations**
- They are expensive to purchase.
- Operators may be afraid of operating computerized equipment.
- Electronic proportioners must be operated by properly trained operators.
- Meters must be checked for accuracy on a regular interval.
Progress Check

After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

1. Isocyanate is a shear sensitive material.
   a. True
   b. False

2. If a piston pump is used to supply isocyanate to a proportioner, what Graco product must be used in the wet cup of the pump to prevent crystallization of the isocyanate on the displacement rod?

3. To prevent the isocyanate from curing up in the hose from the moisture, what hose core materials could you recommend?

4. Name the two equipment solutions to prevent isocyanate from skinning in container.

5. Isocyanate is one of the plural component chemicals used with all plural component materials.
   a. True
   b. False

6. It is important to contact the material supplier for recommended safety procedures when working with isocyanate materials.
   a. True
   b. False
7. Each sentence below describes an advantage or limitation of a plural component proportioning method. Write the letter that best answers the statement in the blank below.

a. Hand Proportioning
b. Mechanical Proportioners
c. Electronic Proportioners
d. B & C
e. A & C
f. A, B, & C

_____ Accurately maintains desired mix ratio, self correcting
_____ Equipment can be difficult and costly to maintain
_____ Efficient method of handling large volumes of plural component materials
_____ No expensive equipment
_____ Can handle multiple ratios
_____ Maintaining ratio within tolerances can be difficult
_____ High percentage of labor costs is used to prepare the material
_____ Cleaner, safer work environment
_____ Color change and purging is faster and generates less waste
_____ Expensive to purchase
_____ Simpler to install in hazardous areas
_____ Work on demand, mixing only what is needed
_____ Provides material usage reports
_____ “Quality of work life” can be an issue due to the nature of some component chemicals
Progress Check Answers

1. False  Isocyanate is a moisture-sensitive material.
2. Iso Pump Oil (IPO). Graco also uses a grease product on one of the 1:1 Fast-Flo™ transfer pumps for isocyanate. These products extend the throat packing life of transfer and proportioning piston pumps.
3. Either PTFE or Polyolefin is recommended.
4. A desiccant dryer or nitrogen supply are common methods to prevent isocyanate skinning in the supply container.
5. False  It is commonly used with polyurethane materials.
6. True

7. C  Electronic Proportioners
   B  Mechanical Proportioners
   B  Mechanical Proportioners
   A  Hand Proportioning
   F  Hand Mixing, Mechanical Proportioners, and Electronic Proportioners
   A  Hand Proportioning
   A  Hand Proportioning
   D  Mechanical Proportioners and Electronic Proportioners
   C  Electronic Proportioners
   C  Electronic Proportioners
   B  Mechanical Proportioners
   D  Mechanical Proportioners and Electronic Proportioners
   C  Electronic Proportioners
   A  Hand Proportioning
Glossary

**Abrasion Resistance**: The ability of a surface to resist wear caused by contact with another material.

**Adhesion, Adhere**: The ability of a material to stick to another material.

**Adhesive**: A substance used to bond two or more pieces so that they can be used as one piece.

**Base Material**: Gives the material its desired properties. Also known as Component A. Component A is the color in a plural component paint.

**Catalyst**: Also known as Component B. The chemical that starts and controls the reaction when Components A and B are mixed in the proper ratio.

**Cavitation**: A condition caused when a pump does not fully load with fluid.

**Chemical Resistance**: The ability of a material to resist damage by chemicals or solvents.

**Coating**: A paint. Any material that will form a continuous film over a surface.

**Color Change**: Changing from one paint color to another. In a mechanical or electronic proportioner this process involves purging the first color from the machine, cleaning the equipment, then priming (filling) the equipment with the new color. The process creates wastes that are expensive to dispose of.

**Component Chemical**: One or two or more chemicals that are mixed together in a prescribed ratio to form a plural component material.

**Cross-Linking**: Also known as curing or polymerization. The chemical process that transforms the component chemicals into a usable material after they have been mixed in the proper ratio.

**Curing or Self Curing**: See Cross-Linking. A process that looks similar to drying. A fluid dries when the solvent evaporates. Another fluid cures when a chemical reaction causes the fluid to harden.

**Decorative Coating**: A paint or coating that is applied to a product to enhance its appearance or attractiveness.

**Durability**: The ability of a material to be useful after a long time and much usage.

**Electronic Proportioner**: The proportioner meters, mixes, and delivers plural component material on demand. The proportioner electronically monitors the meters, providing the ability to proportion the component chemicals very accurately, to print material usage reports, and to shut down automatically if a problem occurs.
**Exothermic Reaction:** A chemical reaction that produces heat as a byproduct.

**Flexibility:** The ability of a material to be flexed or bent repeatedly.

**Foam:** A solidified emulsion filled with air bubbles that is used as thermal insulation, packaging, and in structural components.

**High Solids Materials:** Coatings that have been chemically changed to lower VOC (Volatile Organic Compound) emissions. The chemical change lowers the solvent content and increases the solids content of the fluid.

**Material:** A fluid used in an industrial or manufacturing process as a coating, sealant, adhesive, lubricant or foam.

**Material Characteristics:** The desirable physical characteristics of the cured material. A coating will have good finish quality, a sealant will have good sealing characteristics, and an adhesive will bond properly.

**Material Supplier:** A manufacturer and/or supplier of plural component materials.

**Mechanical Proportioner:** Mechanical proportioners use two or more displacement pumps to measure component chemicals. The pump strokes are synchronized by a mechanical connection. As the pumps operate, they meter out component chemicals in ratios determined by the displacement of the pumps. Fluid is directed from the pumps to a mixing mechanism, then applied to the end product.

**Mix Ratio:** The ratio of Component A to Component B that yields the best characteristics of the end product.

**Off-Ratio:** A condition that exists when a plural component material is blended in a ratio outside the tolerances specified by the material manufacturer. Material characteristics of the cured fluid will not develop properly.

**On-Ratio:** A plural component material that has been properly blended according to the material manufacturer's specification. Material characteristics of the cured fluid will develop properly.

**Plural Component Material:** Plural component materials are produced, packaged and delivered to the worksite as two or more different component chemicals. At the work site they are mixed in a specified ratio which results in a chemical reaction that transforms the components into a useful material. Plural component materials are used as coatings, sealants, adhesives, and foams.

**Polymerization:** See Cross-Linking.

**Pot Life:** Starts when the component chemicals are mixed and ends when hardening occurs.

**Production System:** Equipment used to monitor a production process to insure conformance to a standard.
**Protective Coating:** Protective coatings provide one or more of the following qualities to the objects they are applied to: promote adhesion, provide abrasion resistance, chemical resistance, durability, flexibility.

**Pump:** A machine that draws fluid into itself through an inlet port and forces the fluid out through an exhaust port.

**Purge:** To clean or to remove a material from a pump or other equipment.

**Ratio:** A ratio of two quantities A and B. The ratio is expressed as the number of parts of A, to the number of parts of B, in the format A:B.

**Ratio Tolerance:** The allowable margin of error for a mix ratio as specified by the material supplier.

**Rework:** To repair a defective manufactured product.

**Scrap:** A rejected, defective manufactured product that must be recycled or disposed of.

**Sealant:** A material used to make a non-leaking joint or connection between two or more components.

**Shearing:** Breakdown of the chemical structure of a material caused by certain mechanical components of material handling equipment.

**Spray Life:** Spray life begins after the components are mixed and ends when the coating no longer provides an acceptable finish.

**Synchronized:** The pumps in a mechanical proportioner are connected so that they run at the same cycle rate.

**Viscosity:** The resistance to flow of a liquid. Viscosity may also be expressed as thickness or thinness of a fluid.

**VOC:** Volatile Organic Compounds

**Waterborne Materials:** Materials that have water as part of their chemistry.

**Working Pot Life:** The time period that starts when the component chemicals are mixed and ends when the material no longer provides good material characteristics. See Material Characteristics.

**Work Time:** Work time begins after the components are mixed and ends when the material no longer provides acceptable material characteristics.