INTRODUCTION:

A. Problem Analysis in General:

1. Direct Techniques:
2. Indirect Techniques:
   a. Impressions =
   b. Models, Dies =
   c. Waxing =
   d. Investing =
   e. Casting =
   f. Finishing, Polishing =
   g. Cementation =

(WHAT ARE THE LIMITS FOR DIMENSIONAL ERROR?)

B. Classification Systems for Impression Materials (based on mechanical properties):

<table>
<thead>
<tr>
<th>Rigid:</th>
<th>Props:</th>
<th>Rx:</th>
<th>Set:</th>
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<tbody>
<tr>
<td>Impression Plaster</td>
<td>Rigid</td>
<td>Irrev</td>
<td>(Chem)</td>
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<tr>
<td>Impression Compound</td>
<td>Rigid</td>
<td>Rev</td>
<td>(Phys)</td>
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<tr>
<td>Zinc Oxide/ Eugenol</td>
<td>Rigid</td>
<td>Irrev</td>
<td>(Chem)</td>
</tr>
</tbody>
</table>

Water-Based Gel:

4. Alginate (Irreversible Hydrocolloid) Flexible Irrev (Chem)
5. Agar-Agar (Reversible Hydrocolloid) Flexible Rev (Phys)

Elastomers:

6. Polysulfide (Rubber Base, Thiokol) Flexible Irrev (Chem)
7. Silicone (Conventional, Condensation) Flexible Irrev (Chem)
8. Polyether Flexible Irrev (Chem)
9. Polyvinyl Siloxane (Addition Silicone) Flexible Irrev (Chem)

C. Problem Analysis for Impression Materials:

1. Materials Structure:
2. Materials Properties:
   a. Accuracy (improved by making “hydrophilic” versions of impression materials)
   b. Dimensional Stability
   c. Tear Resistance
3. Materials Manipulation:

D. General Formulation of Elastic Impression Materials (COMPOSITE ANALYSIS):

1. Flexible Matrix (Continuous Phase):
   a. Multifunctional Pre-Polymer or Polymer
   b. Crosslinking Agent
   c. Curing Agent (Catalyst or Initiator)
   d. Modifiers (Accelerators, Retarders, Plasticizers, Flavoring Agents, Colorants)
2. Filler or Extender (Dispersed Phase):
E. Management of Shrinkage with 2-step technique: (in addition to use of fillers)

1. Light-bodied / Heavy-Bodied Technique, OR
2. Wash Material / Putty Material Technique

F. Mixing and Delivery Systems:

1. Delivery Systems:
   a. Hand-mix (Newtonian or dilatant materials)
   b. Auto-mix gun (pseudoplastic materials)
   c. Auto-mix machine (e.g., PentaMix)
2. Auto-mix gun and machine (Kenic’s mixing tips)

F. Distortion on Continued Reaction After Removal:

1. VPS sets quickly but others not done reacting when impression withdrawn
2. During 20-30’ wait for elastic recovery, some distortion occurs.

G. Rapid Removal Minimizes Plastic Deformation:

1. Polymers are strain rate sensitive
2. Remove impression with SNAP
IRREVERSIBLE RUBBER IMPRESSION MATERIALS:

A. **Polysulfide Rubber** (Rubber Base, Mercaptan, Thiokol Rubber):

1. **Chemical Structure:**
   a. CONTINUOUS PHASE:
      
      - **Polymer**
      - **Crosslinking Agent**
      - **Catalysts**

      CONTINUOUS PHASE:
      - Mercaptan Functional Polysulfide
      - Sulfur and/or Lead Peroxide
      - PbO₂ or Copper Hydroxides (Type I)
      - Zinc Peroxide or Organic Hydroperoxide (Type II)

   b. DISPERSED PHASE:
      
      - **Fillers**

      DISPERSED PHASE:
      - TiO₂
      - Zinc Sulfate
      - Lithopone
      - Calcium Sulfate Dihydrate

   ![Chemical structure diagram](image)

2. **Setting Reaction Characteristics:**
   b. Exothermic reaction.
   c. Reaction is temperature sensitive.
   d. Polymerization shrinkage: Reaction not completed very quickly.

3. **Manipulation and Technique Considerations:**
   a. Two-step techniques recommended: Reduces air entrapment and surface tension effects.
   b. Material adversely affected by H₂O, saliva, and blood.
   c.* Set impression should be removed quickly - do not rock tray.
   d. No syneresis or imbibition, but distortion due to continued reaction.
   e. Ideally need uniform thickness and at least 2 mm thick for accuracy.
      (1) Adhesive must be thin
      (2) Adhesive must be dry
   f. Paste-Paste Mixing Recommendations:
      (1) Dispense pastes at the top of the mixing pad
      (2) Mix pastes with tip of spatula only for 5 seconds
      (3) Transfer mass to fresh surface at center of mixing pad
      (4) Wipe spatula off with paper towel; Strop mass for 15s to constant color
      (5) Load syringe or tray
      (6) Use pad excess to monitor setting time
   g. Pouring of models:
      (1) Wait 20-30 minutes before pour for stress relaxation to occur
      (2) RB is non-reactive with model and die materials
      (3) Be careful of glove powder contamination of impression
      (4) RB can be electroplated
B. **Silicone Rubber (Conventional Silicone, Silicone):**

1. **Chemical Structure:**
   a. **CONTINUOUS PHASE:**
      - **Polymer** = Polydimethyl Siloxane
      - **Crosslinking Agent** = Alkyl Orthosilicate or Organo Hydrogen Siloxane
      - **Catalyst** = Organo Tin Compounds (Not Dibutyl Tin Dilaurate) (Usually Tin Octoate)
      - **Modifiers** = Colorants, Flavors
   
   b. **DISPERSED PHASE:**
      - **Filler** = Silica

2. **Setting Reaction Characteristics:**
   a. Stepwise polymerization reaction: Methanol or ethanol by-products.
   b. Slightly exothermic reaction: Not much heat.
   c. Reaction is temperature sensitive.
   d. Polymerization shrinkage: Reaction not completed quickly.

3. **Manipulation and Technique Considerations:**
   b. Requires mechanical retention or special tray adhesives
   c. No syneresis or imbibition, but continued polymerization shrinkage.
   d. Better dimensional stability than RHC but more expensive
   e. Pouring of models:
      - (1) More flexible so more chance for distortion during removal
      - (2) Wait 20-30 minutes before pour for stress relaxation to occur
C. Polyether:

1. Chemical Structure:
   a. CONTINUOUS PHASE:
      \[
      \begin{align*}
      \text{Polymer} & = \text{Amine Terminated Polyether} \\
      \text{Crosslinking Agent} & = \text{Aromatic Sulfonate} \\
      \text{Catalysts} & = \\
      \text{Modifiers} & = \text{Colorants, Flavorants, Glycol-based Plasticizers.}
      \end{align*}
      \]
   b. DISPERSED PHASE:
      \[
      \text{Filler} = \text{Silica}
      \]

2. Setting Reaction Characteristics:
   a. Stepwise Polymerization Reaction: No by-products.
      (This is an addition version of stepwise polymerization)
   b. Exothermic reaction.
   c. Slightly temperature sensitive reaction.
   d. Polymerization shrinkage: Reaction completed fairly quickly.

3. Manipulation and Technique Considerations:
   a. Excellent impression accuracy and dimensional stability.
   b. Stiff and therefore difficult to remove without rocking.
   c. Break seal and rock slightly to prevent tearing: Low tear resistance.
   d. Negatively affected by H₂O, saliva, and blood.
      (1) Since hydrophobic, moisture increases marginal discrepancy
      (2) Increased water absorption occurs if use thinning agents
   e. Can be dispensed from automated extruder and mixer (ESPE PentaMix)

1. Chemical Structure:
   a. CONTINUOUS PHASE:
      - Polymer = Double-bond Functional Silicone Polymer
      - Crosslinking Agent = Chloroplatinic Acid
      - (or Initiator or Catalyst)
      - Modifiers = Colorants, Flavorants, Plasticizer
   b. DISPERSED PHASE:
      - Filler = Silica

2. Setting Reaction Characteristics:
   a. Chain Reaction Polymerization: By-product of H₂ gas from initiator decomposition and initiation reaction.
   b. Moderately exothermic reaction.
   c. Polymerization shrinkage: Reaction completed very quickly.

3. Manipulation and Technique Considerations:
   a. BEST impression material for dimensional stability:
      - Pouring should be delayed at least 4 hours for H₂ out-gassing.
      - Pouring can be delayed up to 7-to-10 days (or indefinitely).
   b. Stiffness makes removal difficult.
   c. Most material dispensed using auto-mixing gun and mixing tips
### PREVIOUS COMMERCIAL PRODUCTS (1980-1995):

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<tr>
<th>Manufacturer</th>
<th>Polysulfide</th>
<th>Conv. Silicone</th>
<th>Polyether</th>
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COMPARISON OF MAJOR CHARACTERISTICS: Flexible Impression Materials

A. Physical, Chemical, Mechanical Props:

(ALG= Alginate; RHC= Reversible Hydrocolloid; PS= Polysulfide Rubber; SIL= Conventional Silicone; PE= Polyether; PVS= Polyvinyl Siloxane or Addition Silicone.)

1. Accuracy (Reproduction of Detail):
   a. Wetting of Tissues: ALG < SIL, PS < PE <= RHC, PVS
   b. Wetting by Dental Stone: SIL, PVS < PS < PE <= ALG, RHC

2. Dimensional Stability: (Resistance to Distortion):
   a. Polymerization Shrinkage
   b. Thermal Shrinkage
   c. Loss of Components
   d. Stress Relaxation
   ALG <= RHC < PS, SIL < PE, PVS

3. Tear Resistance (Elasticity): ALG, RHC, PE < PVS, SIL < PS
   a. Elastic Deformation
   b. Strain Rate Sensitivity

B. Clinical Properties: Which one is the best?

1. Patient Acceptability:
2. Biocompatibility:
3. Mixing and Manipulation Requirements:
4. Requirements for Impression Pouring:

C. Financial Considerations: Which one is the best?

1. Shelf-Life:
2. Cost:
DETAILED ANALYSES OF DIMENSIONAL STABILITY:

A. Dimensional Stability (as a function of the time of pouring):

B. Dimensional Stability (as a function of reaction conversion):
MULTIPLE CHOICE STUDY QUESTIONS:

1. Which one of the following impression materials is elastic, sets by a chemical reaction, and is catalyzed by lead peroxide?
   a. Irreversible Hydrocolloid
   b. Rubber Base
   c. Polyether
   d. Conventional Silicone Rubber
   e. Polyvinyl Siloxane

2. Which one of the following impression materials is elastic, sets by a physical reaction, and is subject to syneresis and imbibition?
   a. Irreversible Hydrocolloid
   b. Reversible Hydrocolloid
   c. Polysulfide Rubber
   d. Condensation Silicone
   e. Polyether

3. Which one of the following impression materials is inelastic, sets by a chemical reaction, and involves an acid-base setting mechanism?
   a. Impression Plaster
   b. Zinc Oxide Eugenol
   c. Alginate
   d. Agar-Agar
   e. Thiokol Rubber

4. Which one of the following impression materials is inelastic, sets by a physical reaction, and is categorized as a thermoplastic material?
   a. Impression Plaster
   b. Zinc Oxide Eugenol
   c. Impression Compound
   d. Polysulfide Rubber
   e. Polyether

5. Which one of the following impression materials is elastic, sets by a chemical reaction, and does not produce by-products during the reaction?
   a. Polysulfide Rubber
   b. Condensation Silicone
   c. Polyvinyl Siloxane
   d. Polyether Rubber

6. Which one of the following impression materials does NOT set by a stepwise polymerization reaction?
   a. Polysulfide Rubber
   b. Conventional Silicone Rubber
   c. Polyether Rubber
   d. Polyvinyl Siloxane

7. The general design for all impression materials can be described in which one of the following ways?
   a. Filler Phase and Catalyst Phase
   b. Crosslinking Agent and Flexible Matrix
   c. Continuous Phase and Dispersed Phase
   d. Dispersed Phase and Modifier Phase
8. All rubber impression materials include fillers principally to:
   a. Reduce the viscosity
   b. Improve the wetting with tooth structure
   c. Increase the tensile strength
   d. Reduce the cost
   e. Reduce the extent of polymerization shrinkage

9. What is the typical level of filler (weight percent) in heavy bodied impression materials?
   a. 60%
   b. 45%
   c. 30%
   d. 15%
   e. 0%

10. What is the mechanism by which filler additions reduce polymerization shrinkage?
    a. Rule-of-Mixtures dilution
    b. Retardation of the setting reaction
    c. Reduction in the percent conversion
    d. Direct reaction with the continuous phase
    e. Adsorption of water by imbibition

11. Which one of the following rubber impression material consistencies contains the greatest amount of filler?
    a. Heavy bodied material
    b. Medium bodied material
    c. Wash material
    d. Light bodied material
    e. Syringed material

12. Which one of the following represents the major component in the chemical composition of the continuous phase of polysulfide impression material?
    a. Mercaptan functional polymer
    b. Polydimethyl silicone
    c. Amine-terminated polyether
    d. Double bond functional silicone polymer

13. Polysulfide impression material sets by which one of the following mechanisms?
    a. Chain reaction polymerization
    b. Stepwise polymerization
    c. Addition polymerization
    d. Chelation
    e. Cooling

14. The matrix phase of polysulfide impression material generally is catalyzed or crosslinked by which one of the following materials?
    a. PbO2
    b. TiO2
    c. CaSO4·H2O
    d. ZnO
    e. SiO2

15. Conventional silicone rubber sets by which one of the following mechanisms?
    a. Addition polymerization
    b. Stepwise polymerization
    c. Chain reaction polymerization
    d. Chelation
    e. Cooling
16. Polyvinyl siloxane impression materials set by which one of the following mechanisms?
   a. Chelation reactions
   b. Stepwise polymerization
   c. Chain reaction polymerization
   d. Cooling

17. Controlled temperature and relative humidity are important considerations for the setting of which ONE of the following impression materials?
   a. Impression Plaster
   b. Impression Compound
   c. Alginate
   d. Polysulfide Rubber
   e. Conventional Silicone Rubber

18. Controlled temperature and relative humidity are important considerations for the setting of which ONE of the following impression materials?
   a. Zinc Oxide Eugenol
   b. Polyether
   c. Alginate
   d. Conventional Silicone Rubber
   e. Impression Plaster

19. The most important characteristic for an elastic impression material is:
   a. Close adaptation to the soft tissues
   b. Withdrawal without permanent deformation
   c. Reproduction of surface detail
   d. Retraction of gingival tissue
   e. Compatibility with all gypsum products

20. What is the range of polymerization shrinkage values for rubber impression materials that are poured at 30 minutes after removal?
   a. 0.40 to 1.00 %
   b. 0.40 to 0.50 %
   c. 0.20 to 0.40 %
   d. 0.05 to 0.20 %
   e. 0.01 to 0.20 %

21. What is desirable level for polymerization shrinkage for rubber impression materials?
   a. < 2.00 %
   b. < 1.00 %
   c. < 0.50 %
   d. < 0.30 %
   e. < 0.20 %

22. During polymerization shrinkage, which direction does the distortion occur?
   a. Toward the impression material tray
   b. Toward the occlusal surfaces of the teeth
   c. Toward the direction of gravitational force
   d. Toward the lingual and labial borders of the tray
   e. Toward the distal portions of the material in the tray
23. Elastic impression materials that undergo shrinkage during setting, cause the final extracoronal casting to be:
   a. Oversized
   b. Exactly the correct size
   c. Slightly undersized
   d. Significantly undersized
   e. Distorted mesially and distally

24. The correct reason for using a two-step impression technique with light bodied and heavy bodied polysulfide impression material is:
   a. To limit the overall polymerization shrinkage
   b. To provide a stronger impression after setting
   c. Because the tray adhesive will not stick to light bodied material.
   d. To control the setting time

25. The mechanical reason for rapid removal of elastic impression materials is because of:
   a. Strain rate sensitivity
   b. Inadequate elastic deformation
   c. Poor tear strength
   d. Low modulus

26. The major advantage of custom impression trays is that they:
   a. Guarantee dimensional stability of the impression material
   b. Facilitate adhesion to the impression material
   c. Promote even thickness of the impression material
   d. Aid in tray removal

27. Inaccuracy of elastic impression materials is caused by:
   a. Unequal pressure during impression making.
   b. Premature removal of the impression tray.
   c. Slow removal of the impression tray.
   d. All of the above.

28. Elastic impression materials are more accurate than reversible hydrocolloid.
   a. True
   b. False

29. Which one of the following factors influences the setting time of polysulfide rubber?
   a. Ratio of the pastes
   b. Temperature
   c. Relative Humidity
   d. All of the above

30. Which one of the following materials undergoes syneresis?
   a. Alginate
   b. Rubber Base
   c. Polyether
   d. Impression Compound
   e. Silicone Rubber

31. Which ONE of the following is the correct appearance for the use of impression tray adhesives?
   a. Thick and wet
   b. Thin and wet
   c. Thick and dry
   d. Thin and dry
32. Which one of the following is the correct procedure for cleaning the surfaces of rubber impression materials prior to pouring with gypsum products?
   a. Gently clean with water and dry with air.
   b. Soak in soapy water and air dry.
   c. Rinse and towel dry.
   d. Use air-water spray to wash and dry upside down.
   e. Air dry.

33. Which one of the following is the proper way to release a hydrostatic seal without distorting the impression?
   a. Lift up the gingival edge away from the area of importance.
   b. Gently wiggle the impression tray.
   c. Rock the impression tray up and down.
   d. Roll the impression tray during tray removal.
   e. Twist the impression tray handle.

34. Which one of the following ways can you tell the compatibility of gypsum products with the impression material being used?
   a. Manufacturer's instructions for the impression material.
   b. Manufacturer's instructions for the gypsum products.
   c. ADA seal of certification for the impression material.
   d. ADA seal of certification for the gypsum product.

35. Which one of the following ways is the proper way to tell when an impression material kit is no longer any good?
   a. Check the expiration date.
   b. Mix the pastes together and check the setting time.
   c. Check the texture of the material by squeezing the tubes.
   d. None of the above.

36. Which one of the following impressions can be poured after a 2-day delay without worry for continuing distortion due to shrinkage?
   a. Reversible Hydrocolloid
   b. Polysulfide Rubber
   c. Conventional Silicone Rubber
   d. Polyether
   e. Polyvinyl Siloxane

37. A general rule-of-thumb for using impression materials is to wait before impression tray removal for a time that is:
   a. Longer than recommended by the manufacturer.
   b. Exactly the same as recommended by the manufacturer.
   c. Shorter than the time recommended by the manufacturer.
   d. Equal to the time recommended by the ADA certification standards.
   e. Different for each patient.

38. What is the biocompatibility of impression materials?
   a. Inert.
   b. Non-toxic.
   c. Unknown but apparently non-toxic.
   d. Unknown but potentially toxic.
39. Which one of the following types of materials is routinely supplied as an auto-mixing system?
   a. Polysulfide
   b. Condensation Silicone
   c. Polyether
   d. Polyvinyl Siloxane

40. Which one of the following types of materials is supplied using an electric mixing and delivery device?
   a. Polysulfide
   b. Condensation Silicone
   c. Polyether
   d. Polyvinyl Siloxane

41. Which of the following delivery systems is not currently available for impression materials?
   a. Hand mix
   b. Auto-mix (syringe)
   c. Auto-mix (Penta)
   d. No mix, visible light cure
   e. Auto-mix (garant)

42. Which of the following is the best type of impression material tray for quadrant impressions?
   a. Custom tray with adhesive
   b. Plastic tray with adhesive
   c. Re-usable perforated metal tray without adhesive
   d. Rim-lock tray without adhesive
   e. Plastic tray without adhesive

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