INTRODUCTION:

A. Historical Background

1. Au-alloys initially; Cr-alloys since 1930s and widely used since 1970s
2. Advantages: good corrosion resistance, high strength, high E, low density, low $$$
3. Compositions similar to ones used for C&B, MF, and orthopedic implants

B. Classification of RPD Alloys

1. RPD components = cast framework, clasps, wrought retention wires, solders
2. Framework casting alloys:
   a. (Gold Casting Alloys [Type IV]) = ……
   b. Co-Cr
   c. Co-Cr-Ni
   d. Ni-Cr (and Ni-Cr-Be)
   e. (Fe-Cr)
   f. (Ti-6Al-4V) (cpTi)
   g. (Ni-Ti)

ANALYSIS OF RPD ALLOY PROPERTIES

A. Properties of Key Base Metal RPD Alloys: (Co-Cr, Ni-Cr)

1. Physical Properties:
   a. Typical fusion temperatures = 1400 to 1454 °C
   b. Color = lustrous silvery white
   c. Density (lighter weight than gold counterparts) = typically 8-9 gm/cm³
   d. Linear casting shrinkage = 2.05 to 2.33% (vs 1.4 to 1.7% for gold alloys)
   e. Thermal conductivity = high

2. Chemical Properties:
   a. Electrochemical corrosion = good passivation by Cr₂O₃ if Ni-Cr-Co >85%
   b. Passive film attacked vigorously by chlorine -- do not use household bleach

3. Mechanical Properties:
   a. E = 200-240 GPa (about 2X that of comparable cast dental gold)
   b. Hardness (typically 30% harder than Type IV golds) = R30N (or VHN) = 370
   c. YS = 414-621 MPa, UTS = 621-828 MPa
   d. % Elongation (Cr alloys are quite brittle) = 1-2%
   e. Co-Cr alloys not affected by HT; Ni-Cr alloys can be affected by high temp HT
   f. Fatigue much more important for clasps than connectors
4. **Laboratory Manipulation:**
   a. Investment (requires high temperature investments) = PBI or SBI
   b. Spruing (entrapped gases may produce voids) = careful venting
   c. Melting methods = oxyacetylene, oxygen-gas, or electric induction
   d. Casting (broken-arm casting machines not recommended) = vacuum, pressure
   e. Sprue removal and finishing/polishing = special lab equipment due to high H
   f. Soldering = use care in fluxing, soldering, and heat control (electric soldering)
   g. Solders = usually >800 fine Ag-solders (good corrosion resistance)
   h. Sterilization = dilute bleach solutions

5. **Clinical properties:**
   a. Adjustments (casts, etc.) = difficult due to high hardness and E
   b. Ni sensitivity = sometimes but probably due to misfit or improper design
   c. Wear = low (but may contribute to excessive wear of teeth or restorations)
   d. Hygiene = clean with soap and water or very dilute solutions avoiding chlorine
      (Use stiff bristle brush; Avoid abrasive dentifrices)

### B. Example of Mechanical Properties of Removable Partial Denture Alloys

<table>
<thead>
<tr>
<th>Alloy Type</th>
<th>Yield Strength (MPa)</th>
<th>Tensile Strength (MPa)</th>
<th>Percent (%)</th>
<th>Hardness (VHN)</th>
<th>Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA Spec #14 Minimum (REF)</td>
<td>500</td>
<td>-----</td>
<td>1.5</td>
<td>-----</td>
<td>172</td>
</tr>
<tr>
<td>Type IV Gold Alloy</td>
<td>493</td>
<td>776</td>
<td>7.</td>
<td>264</td>
<td>90</td>
</tr>
<tr>
<td>Fe-Cr</td>
<td>703</td>
<td>841</td>
<td>9.</td>
<td>309</td>
<td>202</td>
</tr>
<tr>
<td>Co-Cr-Ni</td>
<td>470</td>
<td>685</td>
<td>8.</td>
<td>264</td>
<td>198</td>
</tr>
<tr>
<td>Co-Cr</td>
<td>710</td>
<td>870</td>
<td>1.6</td>
<td>432</td>
<td>224</td>
</tr>
<tr>
<td>Ni-Cr</td>
<td>690</td>
<td>800</td>
<td>3.8</td>
<td>300</td>
<td>182</td>
</tr>
<tr>
<td>Ti-6Al-4V</td>
<td>-----</td>
<td>930</td>
<td>5.</td>
<td>320</td>
<td>117</td>
</tr>
<tr>
<td>Others (cpTi, Ni-Ti)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### C. Biomechanical Analysis of RPD:

1. Combinations and permutations
   a. Indicated to some degree by complex RPD classification system
   b. Literally thousands of designs versus different patient physiologic conditions
   c. Half-life of good diagnosis, design, and function = 3-5 years (redone in 5-8 yrs)

2. Complex overall RPD design contributes to failure
   a. 4 degrees of freedom -- x, y, z, and rotation
   b. General categories of failures
      (1) BIOLOGIC =
      (2) FUNCTIONAL =
      (3) MATERIALS =
   c. MATERIALS failures:
      (1) Fatigue fracture of cast clasps, soldered retainers, occlusal rests
      (2) Distortion or breakage of major and minor connectors (patient abuse causes strain hardening) – recast failed section and attach by soldering.
      (3) Loss of tooth or teeth or staining or interface between teeth and acrylic

3. Analysis of components of RPD:
   a. Major and minor connectors: need stiffness = low deflection
      (1) Deflection = \((4)(P)(Length^3) / (E)(Width)(Thickness^3)\)
      (2) Geometric effects of design – tear drop and half-round are ideal
   b. Clasps and retentive wires -- need flexibility
   c. Acrylic saddles -- need adhesion to framework
**MULTIPLE CHOICE STUDY QUESTIONS:**

1. When did base metal alloys become popular for use for RPD frameworks?
   a. 1930s
   b. 1950s
   c. 1970s
   d. 1990s
   e. Recently

2. Which one of the following alloys is not a base-metal alloy system?
   a. Au-Cu-Pt-Pd
   b. Co-Cr
   c. Fe-Cr
   d. Ni-Cr
   e. Ti-6Al-4V

3. Which alloys are most popular for RPD construction?
   a. Co-Cr, Fe-Cr
   b. Ni-Cr, Ti-6Al-4V
   c. Au-Cu-Pt-Pd, Co-Cr-Ni
   d. Au-Cu-Pt-Pd, Ni-Cr
   e. Co-Cr, Ni-Cr

4. What describes the melting and casting challenges for base metal RPD alloys?
   a. Low melting temperature
   b. Low melting temperature but reacts with GBI
   c. Medium melting temperature
   d. Medium melting temperature but reacts with PBI
   e. High melting temperature

5. Why are RPD base-metal alloys corrosion resistant?
   a. Immunity of the alloys
   b. Passivation
   c. Absence of any electrochemical cells
   d. Laboratory coatings that are electroplated onto the casting alloy
6. What is the major protective coating on base-metal alloys?
   a. Aluminum oxide
   b. Gold
   c. Nickel
   d. Chromium oxide
   e. Cobalt nitride

7. Which of the following is NOT a major consideration for casting RPD base-metal alloys?
   a. Addition of Sn or In for bonding acrylic resin to RPD
   b. Special type of investment (PBI or SBI)
   c. Special tools for removal of casting sprues and for finishing and polishing
   d. Use of high temperature torches or induction melting for casting alloy
   e. Vacuum and/or pressure casting to accommodate low density of base metal alloys

8. Which of the following statements is true?
   a. Gold alloys have about three times as great an elastic modulus as Co-Cr alloys
   b. Titanium alloys have the greatest stiffness of all base metal alloys
   c. Finishing/polishing operations of RPD alloys are facilitated by their high hardness.
   d. Base metal alloys have about twice as great a modulus as gold-based alloys
   e. All base metal alloys are routinely heat-treated to increase their stiffness

9. Which of the following is the most effective method for maximizing the stiffness of a major connector?
   a. Choose the material with the highest possible modulus
   b. Increase the thickness of the connector
   c. Change the cross-sectional shape of the connector to triangular
   d. Change the cross-sectional shape of the connector to round
   e. Heat-treat the casting after finishing it

10. What is the typical range of shrinkage of RPD casting alloys on cooling?
    (Remember that most gold casting alloys for crowns shrink about 1.4 to 1.7%)
    a. 1.0-to-1.3%
    b. 1.3-to-1.6%
    c. 1.5-to-1.7%
    d. 1.9-to-2.0%
    e. 2.1-to-2.3%

11. Which of the following is TRUE for soldered RPD joints?
    a. Solder has better corrosion resistance than RPD alloy
    b. Better fatigue resistance
    c. Higher tensile strength to RPD alloy
    d. Higher modulus than the RPD alloy
    e. Difficult to finish and polish

12. Which way(s) are preferred for attachment of a clasp to an RPD?
    a. Gold soldering
    b. Silver soldering
    c. Spot welding
    d. Bonding
    e. Laser welding

13. What is the preferred method of sterilization of RPD prostheses?
    a. High-heat sterilization
    b. Glutaraldehyde soak
    c. Dilute bleach wash
    d. Ionizing radiation
14. Which one of the following items might produce accelerated corrosion of RPD alloy if used daily for cleansing procedures?
   a. Chlorine containing materials (e.g., bleach)
   b. Fluoride containing dentifrices
   c. Abrasive toothpastes
   d. Antibacterial soaps
   e. Powered toothbrushes

15. What is the typical half-life (when it will be redone) for a RPD?
   a. 3-5 years
   b. 5-8 years
   c. 8-12 years
   d. 12-20 years
   e. >20 years

16. Which one(s) of the following changes is most often responsible for RPD failure?
   a. Biologic changes due to bone resorption or tooth mobility
   b. Functional changes due to non-vertical stresses
   c. Functional changes due to PDF overloads
   d. Materials changes due to corrosion
   e. Materials changes due to work hardening and fatigue fracture

**DISCUSSION STUDY QUESTIONS:**

- You patient appears to be nickel sensitive. Is nickel released from nickel containing base metal alloys? What is the actual surface of the alloy after finishing and polishing? How would you test for this condition of sensitivity? What would you recommend for an alternative RPD alloy under these circumstances?
- A clasp on RPD is broken in service. Can it be repaired chairside by bonding the pieces together? Can it be repaired by soldering?
- What would you recommend to add to the facial surfaces of clasps to make them more esthetic in appearance?
- How can you tell the composition of an RPD alloy when the patient presents to you for the first time?
- An RPD has tarnished badly and turned black on all the exposed surfaces. What happened? What can you do? Is the RPD irreversibly damaged?