Available Training on Reactive Metals

1. **Introduction to Reactive and Refractory Metals**
    a. Brief history and sources of materials
2. **Production Processes**
3. **Applications of Reactive Metal**
    a. Titanium
    b. Zirconium
    c. Tantalum/Niobium
4. **Alloy Grades, Mechanical, Chemical and Physical Properties**
    a. Metallurgy
    b. Alloys
    c. Material properties
5. **Chemical and Physical Properties**
6. **Specifications**
    a. ASTM
    b. ASME
    c. AWS
7. **Fabrication Properties**
    a. Major considerations during equipment fabrication
    b. Formability
    c. Machining and grinding
8. **Corrosion Properties of Reactive and Refractory metal**
9. **Corrosion Processes**
    a. Forms of corrosion
    b. Oxide films
10. **Performance of Reactive and Refractory Metals in Corrosive Media**
    a. Sulfuric acid
    b. Hydrochloric acid
    c. Nitric acid
    d. Phosphoric acid
    e. Organic acids
    f. Chloride media
    g. Alkaline media
11. **Welding of Reactive Metals, Including Weld Inspection**
    a. Considerations when welding reactive metals
12. **Welding Processes, Equipment, Gases, Shielding and Environment**
13. **Welding Parameters and Precautions**
14. **Weld Contamination**
15. **When Weld Heat Treatment is Required**
16. **Weld Quality Tests**
17. **Weld Inspection**
18. **Weld Repair/Field Repair**
19. **Heat Treatment of Reactive Metals**
    a. When HT is required for reactive metals
    b. Types of heat treatments
    c. Cleanliness, proper support, temperature monitoring, atmosphere, etc.
    d. Surface appearance and inspection

20. **Safety**
    a. Health-related issues
    b. Threshold value limits
    c. Toxicity of Ti, Zr and Ta
    d. Fabrication safety
    e. Handling of material
    f. Machining
    g. Grinding
    h. Cutting (flame, water jet)
    i. Welding
    j. Standards on combustible metals and dust
    k. NFPA 484: Standard for Combustible Metals
    l. NFPA 652: Standard on the Fundamentals of Combustible Dust
    m. Storage of material
    n. Solids
    o. Fines (chips, sponge, powder, etc.
    p. Proper disposal of flammable materials
    q. Fire safety
21. **Pyrophoric Reactions of Metals**
    a. Pyrophoric film formation
    b. When this occurs in zirconium
    c. Passivation of a pyrophoric film
    d. Steaming of vessels
22. **Equipment Design and Fabrication**
    a. Heat exchangers
        i. Tube-to-tubesheet considerations
        ii. Design, end configuration, grooves, etc.
        iii. Testing processes
        iv. Piping systems
        v. Design and fabrication configurations
        vi. Types of fittings and flanges
23. **Columns**
    a. Trays and internals
    b. Fasteners
24. **Pressure Vessels**
    a. Clad or solid
25. **Inspection Techniques for Vessels**
26. **Explosion Cladding**
27. **Equipment Maintenance and Operation**
    a. Maintenance requirements
    b. Operation considerations
28. **Reactive Metal Equipment Cleaning**
    a. Mechanical cleaning
    b. Chemical cleaning

Reactive Metal Weld Training

1. **Introduction and Overview of Reactive Metal Welding in Industry**
    a. General history of reactive metal welding
2. **Development of Welding Processes**
3. **Fundamentals – Oxygen, Iron, Carbon, Nitrogen, Hydrogen and Titanium or Zirconium**
    a. Titanium
    b. Zirconium
    c. Tantalum (and Niobium)
4. **Effects of Oxygen, Iron, Carbon, Nitrogen, and Hydrogen in Welding**
5. **Base Material**
    a. Titanium
    b. Zirconium
    c. Tantalum/Niobium
6. **Filler Metals, Specifications and Grades**
    a. Specifications
    b. Grade selection
    c. Wire identification and cleanliness
    d. Wire storage
7. **Dissimilar Reactive Metal Welding**
    a. Titanium
    b. Zirconium
    c. Tantalum/Niobium
8. **Base Metal and Welding Microstructures**
9. **Heat Treatment of Welds**
    a. Titanium
    b. Zirconium
10. **Gas Tungsten Arc Welding Process**
11. **Equipment for Manual Welding**
12. **Joint Design and Preparation**
    a. Cleaning
    b. Filler metal
13. **Inert Gas Shielding**
14. **Dew Point Indicators, Oxygen Meters, and Surrogates**
15. **Purging**
16. **Fitting and Tacking**
17. **Welding Procedures and Techniques**
18. **Weld Discontinuities and Defects**
19. **Weld Quality Tests and Checks**
20. **Welder Training and Welder Qualification**
21. **When a Welding Procedure Qualification is <u>not</u> Enough**
22. **Weld Safety**