Maintenance, Lubrication, and Cutting Fluid Overflow

Cutting Fluids—Types and Applications

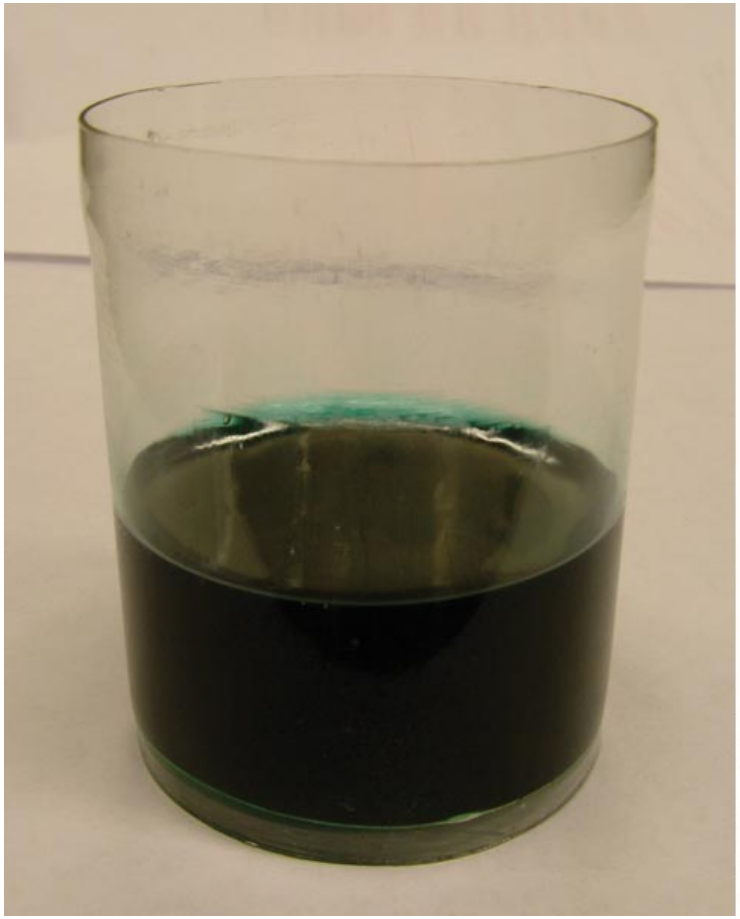
Cutting Fluids

- Substances applied to cutting areas
  - Cool and reduce friction; wash away debris
- May be oil-based or chemical-based
  - Some must be diluted in water
    - Refractometers measure concentrations
  - Some applications use cold air guns or solid/semi-solid cutting compounds instead
  - Methods of application
    - Manual, flood, mist, MQL

An example of a sulfurized, chlorinated cutting oil.

A soluble oil is mixed with water to produce a milky white cutting fluid.

Photo courtesy of Master Chemical Company, a global supplier of industrial metal working products



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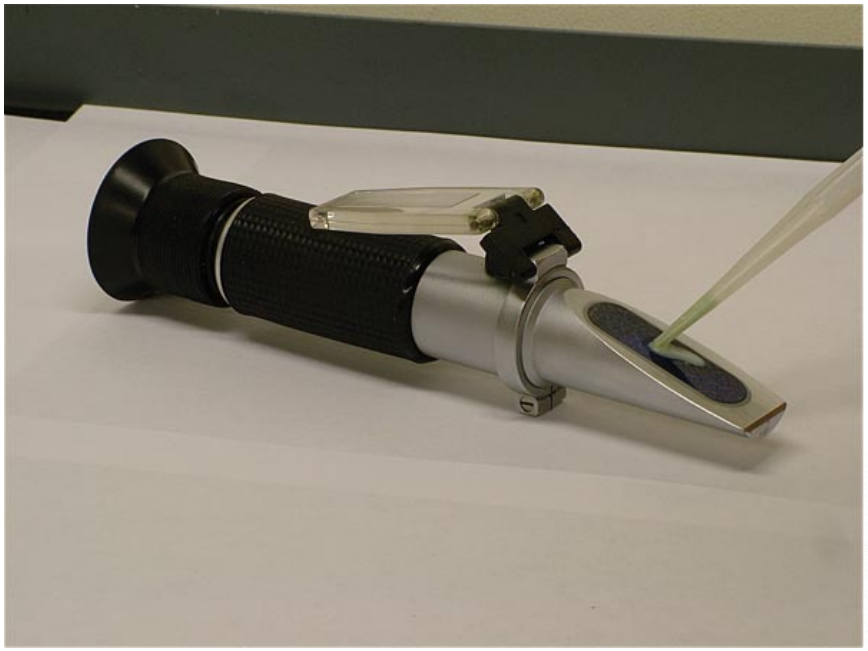
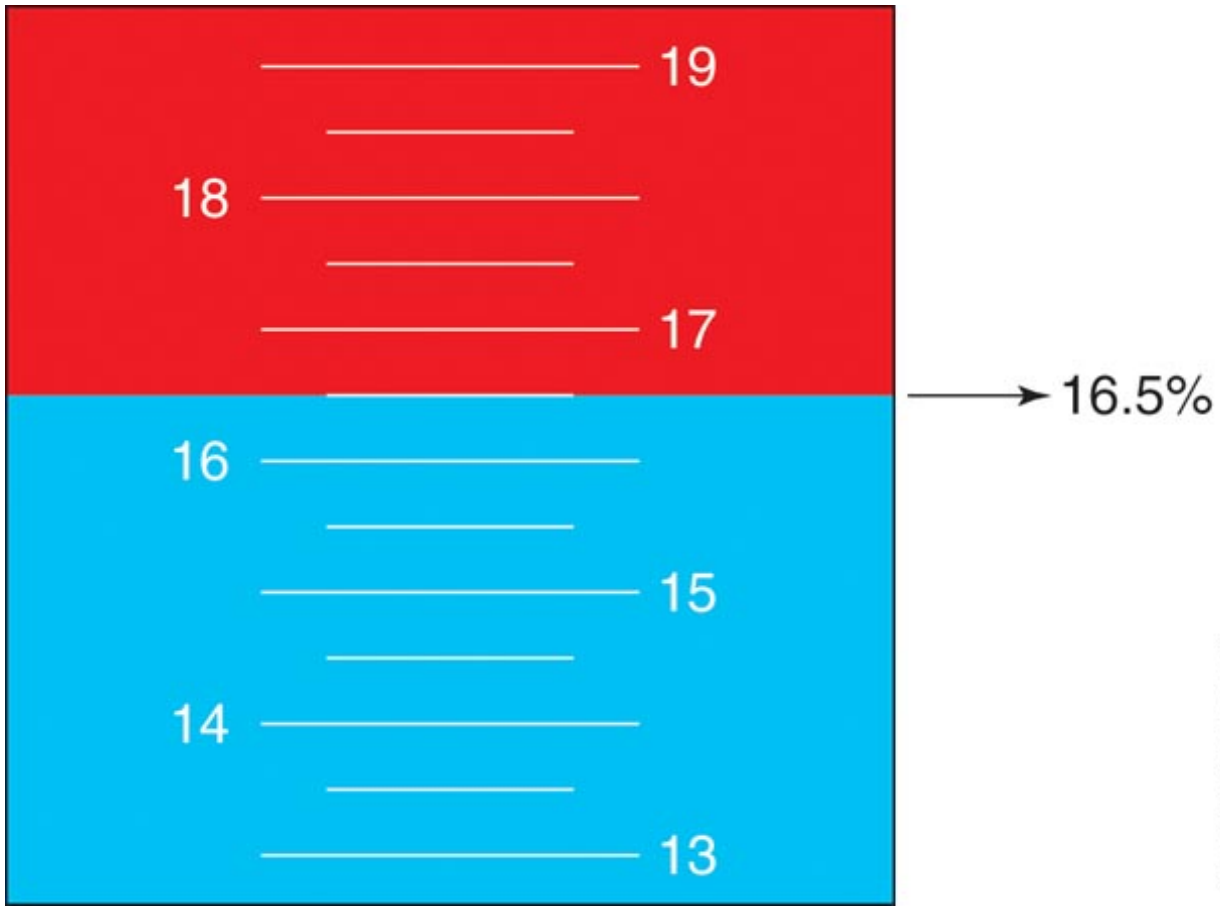


(A) The cutting fluid mixture is placed on the glass of the refractometer. (B) Then the user looks through the eyepiece to read the scale.



A sample refractometer reading. The scale is read where the two colors meet. This reading is 16.5, which means a 16.5 percent cutting fluid concentration.

A cold air gun being used to provide cooling during a milling operation.

Cutting Fluids

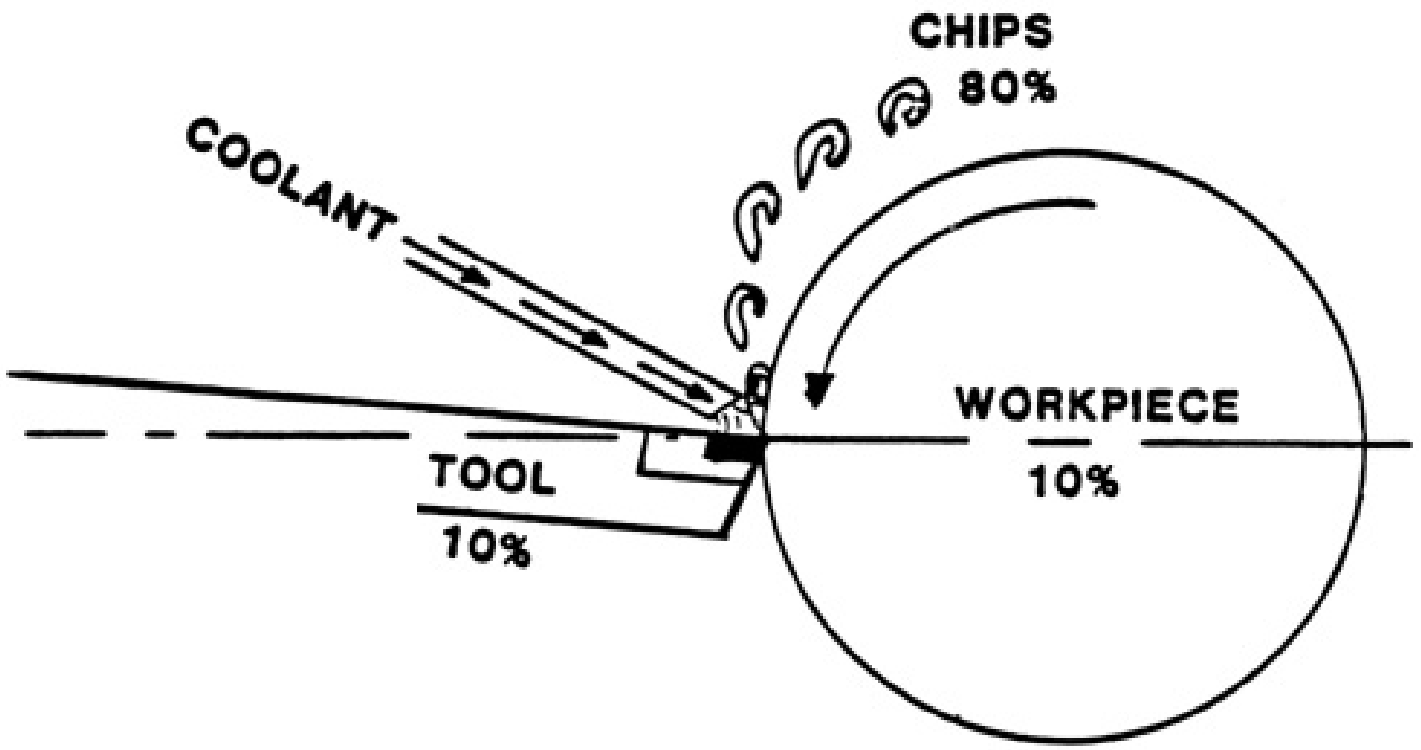
- Essential in metal-cutting operations to reduce heat and friction
- Centuries ago, water used on grindstones
- 100 years ago, tallow used (did not cool)
- Lard oils came later but turned rancid
- Early 20th century saw soap added to water
- Soluble oils came in 1936
- Chemical cutting fluids introduced in 1944

Economic Advantages to Using Cutting Fluids

- Reduction of tool costs
  - Reduce tool wear, tools last longer
- Increased speed of production
  - Reduce heat and friction so higher cutting speeds
- Reduction of labor costs
  - Tools last longer and require less regrinding, less downtime, reducing cost per part
- Reduction of power costs
  - Friction reduced so less power required by machining

Heat Generated During Machining

- Heat find its way into one of three places
  - Workpiece, tool, chips



Heat Dissipation

- Ideally most heat taken off in chips
- Indicated by change in chip color as heat causes chips to oxidize
- Cutting fluids assist taking away heat
  - Can dissipate at least 50% of heat created during machining

Characteristics of a Good Cutting Fluid

1. Good cooling capacity
2. Good lubricating qualities
3. Resistance to rancidity
4. Relatively low viscosity
5. Stability (long life)
6. Rust resistance
7. Nontoxic
8. Transparent
9. Nonflammable

Types of Cutting Fluids

- Most commonly used cutting fluids
  - Either aqueous based solutions or cutting oils
- Fall into three categories
  - Cutting oils
  - Emulsifiable oils
  - Chemical (synthetic) cutting fluids

Cutting Oils

- Two classifications
  - Active
  - Inactive
- Terms relate to oil's chemical activity or ability to react with metal surface
  - Elevated temperatures
  - Improve cutting action
  - Protect surface

Active Cutting Oils

- Those that will darken copper strip immersed for 3 hours at temperature of 212ºF
- Dark or transparent
- Better for heavy-duty jobs
- Three categories
  - Sulfurized mineral oils
  - Sulfochlorinated mineral oils
  - Sulfochlorinated fatty oil blends

Oil Categories

- Sulfurized mineral oils
  - Contain .5% to .8% sulfur
  - Light-colored and transparent
  - Stains copper and alloys
- Sulfochlorinated mineral oils
  - 3% sulfur and 1% chlorine
  - Prevent excessive built-up edges from forming
- Sulfochlorinated fatty oil blends
  - Contain more sulfur than other types

Inactive Cutting Oils

- Oils will not darken copper strip immersed in them for 3 hours at 212ºF
- Contained sulfur is natural
  - Termed inactive because sulfur so firmly attached to oil – very little released
- Four general categories
  - Straight mineral oils, fatty oils, fatty and mineral oil blends, sulfurized fatty-mineral oil blend

Emulsifiable (Soluble) Oils

- Mineral oils containing soaplike material that makes them soluble in water and causes them to adhere to workpiece
- Emulsifiers break oil into minute particles and keep them separated in water
  - Supplied in concentrated form (1-5 /100 water)
- Good cooling and lubricating qualities
- Used at high cutting speeds, low cutting pressures

Three Types of Emulsifiable Oils

1. Emulsifiable mineral oils
   - Mineral oils to which various compounds to make oil soluble in water
2. Superfatted emulsifiable oils
   - Minerals oils with fatty oil added
3. Extreme-pressure emulsifiable oils
   - Contain sulfur, chlorine and phosphorus
   - Mixed 1part oil with 20 parts water

Chemical Cutting Fluids

- Also called synthetic fluids
- Introduced about 1945
- Stable, preformed emulsions
  - Contain very little oil and mix easily with water
- Extreme-pressure (EP) lubricants added
  - React with freshly machined metal under heat and pressure of a cut to form solid lubricant
- Reduce heat of friction and heat caused by plastic deformation of metal

Chemical Agents Found in Synthetic Fluids

1. Amines and nitrites for rust prevention
2. Nitrates for nitrite stabilization
3. Phosphates and borates for water softening
4. Soaps and wetting agents for lubrication
5. Phosphorus, chlorine, and sulfur compounds for chemical lubrication
6. Glycols to act as blending agents
7. Germicides to control bacteria growth

Advantages of Synthetic Fluids

1. Good rust control
2. Resistance to rancidity for long periods of time
3. Reduction of amount of heat generated during cutting
4. Excellent cooling qualities

5. Longer durability than cutting or soluble oils
6. Nonflammable, nonsmoking
7. Nontoxic
8. Easy separation from work and chips
9. Quick setting of grit and fine chips so they are not recirculated in cooling system
10. No clogging of machine cooling system due to detergent action of fluid

Three Types of Chemical Cutting Fluids

1. True solution fluids
   - Contain mostly rust inhibitors
   - Prevent rust and provide rapid heat removal
2. Wetting-agent types
   - Contain agents to improve wetting action of water, provide more uniform heat removal
3. Wetting-agent types with EP lubricants
   - Added chlorine, sulfur or phosphorus

Functions of a Cutting Fluid

- Prime functions
  - Provide cooling
  - Provide lubrication
- Other functions
  - Prolong cutting-tool life
  - Provide rust control
  - Resist rancidity

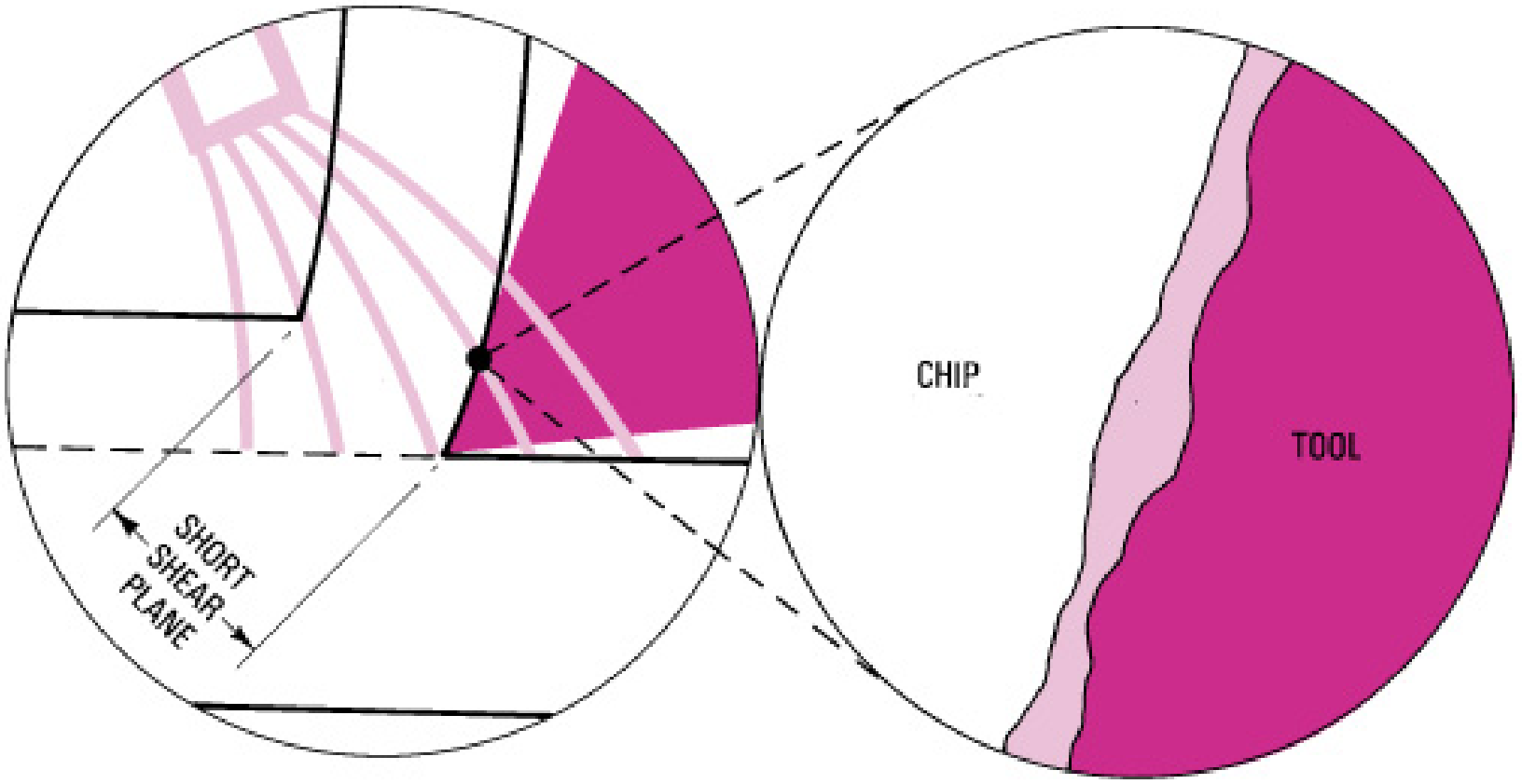
Functions of a Cutting Fluid: Cooling

- Heat has definite bearing on cutting-tool wear
  - Small reduction will greatly extend tool life
- Two sources of heat during cutting action
  - Plastic deformation of metal
    - Occurs immediately ahead of cutting tool
    - Accounts for 2/3 to 3/4 of heat
  - Friction from chip sliding along cutting-tool face
- Water most effective for reducing heat (rust)

Functions of a Cutting Fluid: Lubrication

- Reduces friction between chip and tool face
  - Shear plane becomes shorter
  - Area where plastic deformation occurs correspondingly smaller
- Extreme-pressure lubricants reduce amount of heat-producing friction
- EP chemicals of synthetic fluids combine chemically with sheared metal of chip to form solid compounds (allow chip to slide)

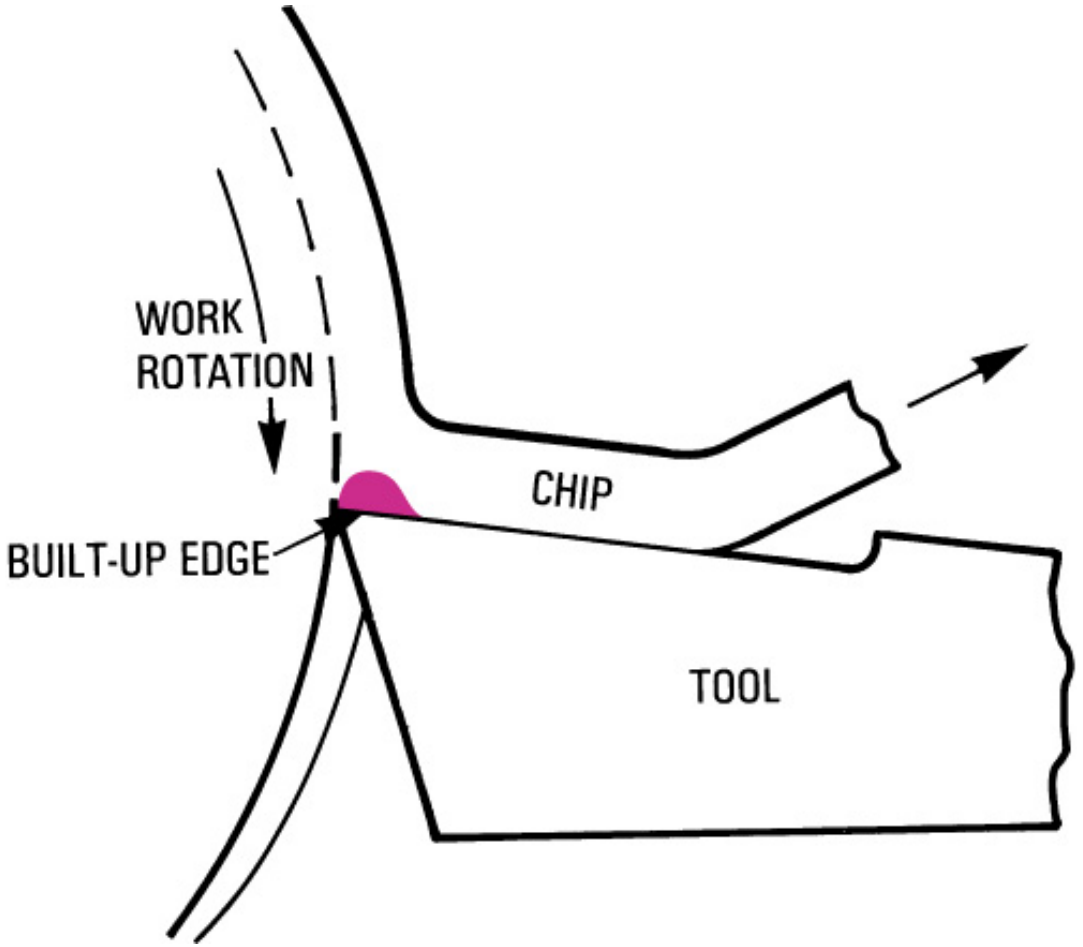
Cutting fluid reduces friction and produces a shorter shear plane.



Cutting-Tool Life

- Heat and friction prime causes of cutting-tool breakdown
- Reduce temperature by as little as 50ºF, life of cutting tool increases fivefold
- Built-up edge
  - Pieces of metal weld themselves to tool face
  - Becomes large and flat along tool face, effective rake angle of cutting tool decreased

Built-up Edge



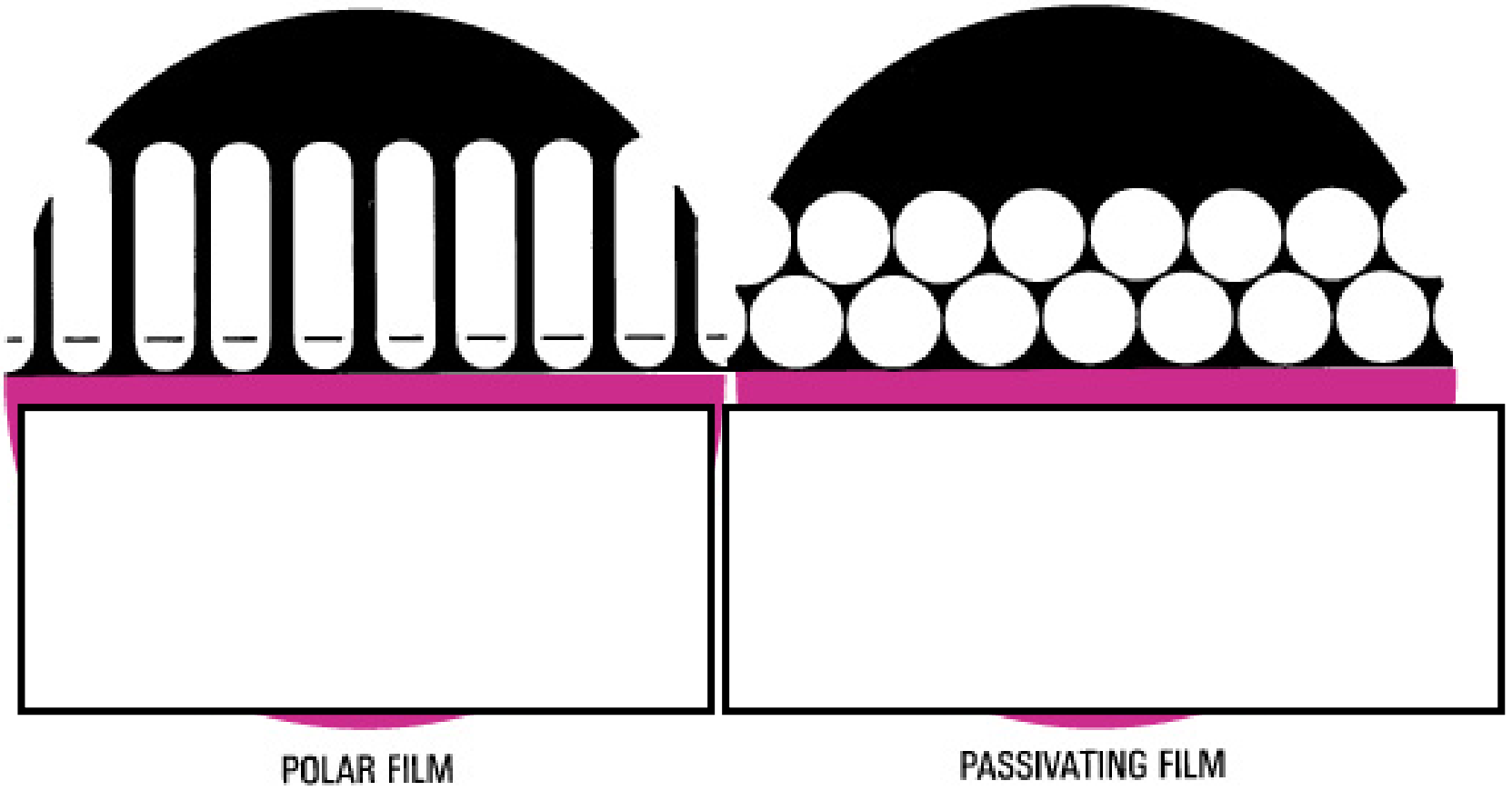
Cutting Fluid's Effect on Cutting Tool Action

1. Lowers heat created by plastic deformation of metal
2. Friction at chip-tool interface decreased
3. Less power is required for machining because of reduced friction
4. Prevents built-up edge from forming
5. Surface finish of work greatly improved

Rust Control

- Water best and most economical coolant
  - Causes parts to rust
- Rust is oxidized iron
- Chemical cutting fluids contain rust inhibitors
  - Polar film
  - Passivating film

Rust Inhibitor Films



Rancidity Control

- Rancidity caused by bacteria and other microscopic organisms, growing and eventually causing bad odors to form
- Most cutting fluids contain bactericides that control growth of bacteria and make fluids more resistant to rancidity

Application of Cutting Fluids

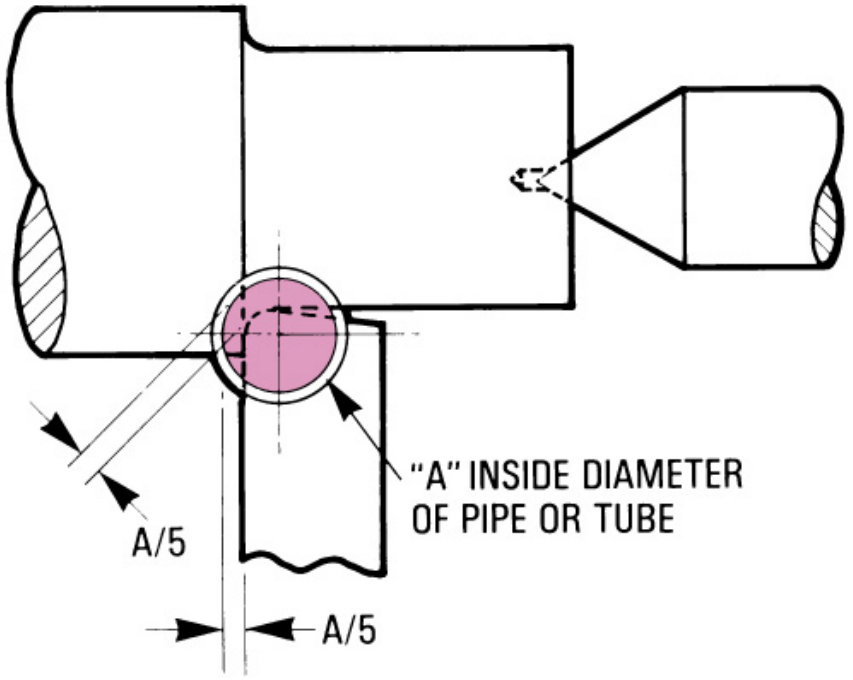
- Cutting-tool life and machining operations influenced by way cutting fluid applied
- Copious stream under low pressure so work and tool well covered
  - Inside diameter of supply nozzle ¾ width of cutting tool
  - Applied to where chip being formed

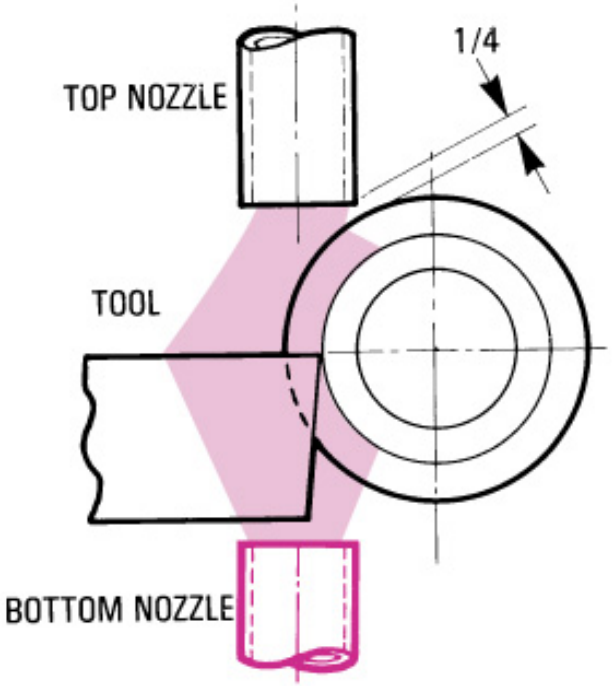
Refrigerated Air System

- Another way to cool chip-tool interface
- Effective, inexpensive and readily available
- Used where dry machining is necessary
- Uses compressed air that enters vortex generation chamber
  - Cooled 100ºF below incoming air
- Air directed to interface and blow chips away

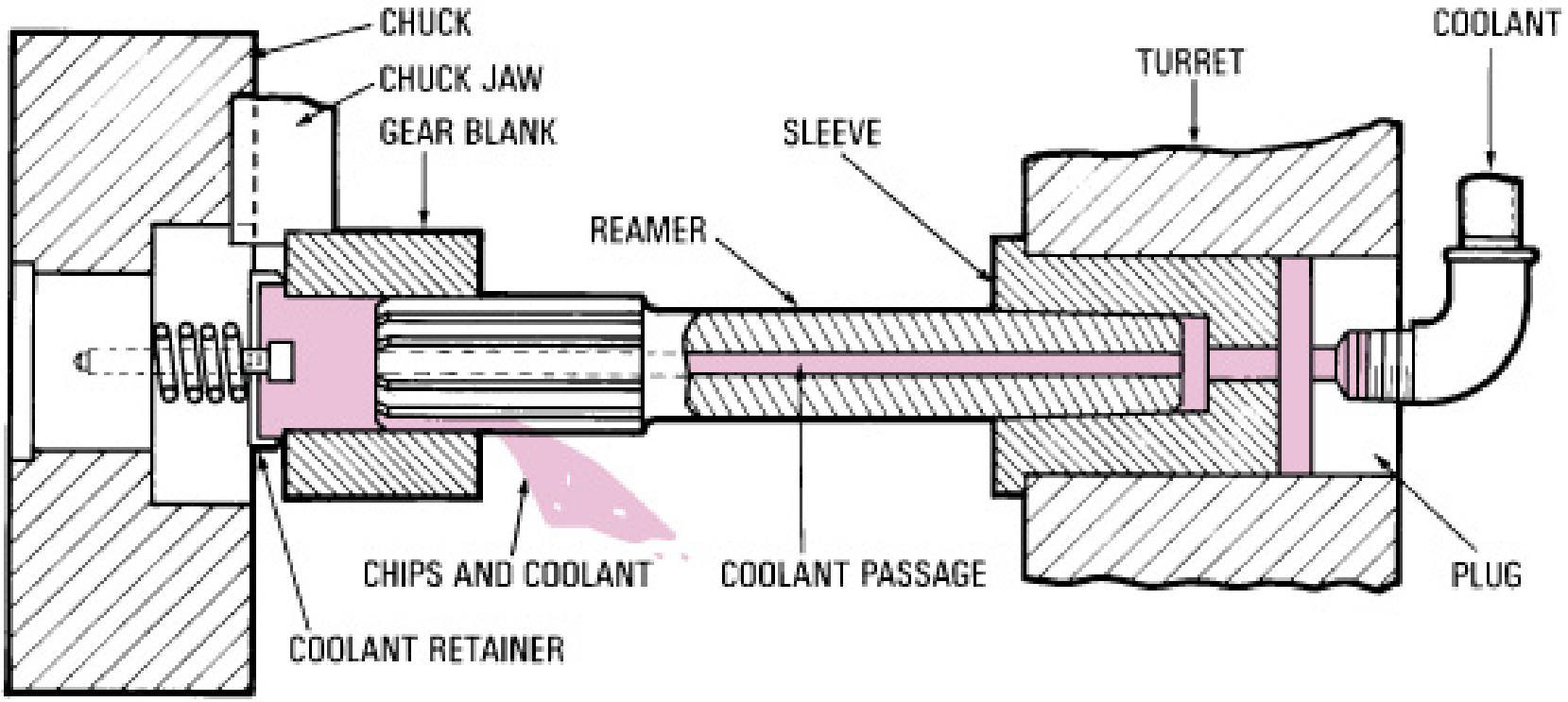
Lathe-Type Operations

- Cutting fluid should be applied to that portion of cutting tool producing chip



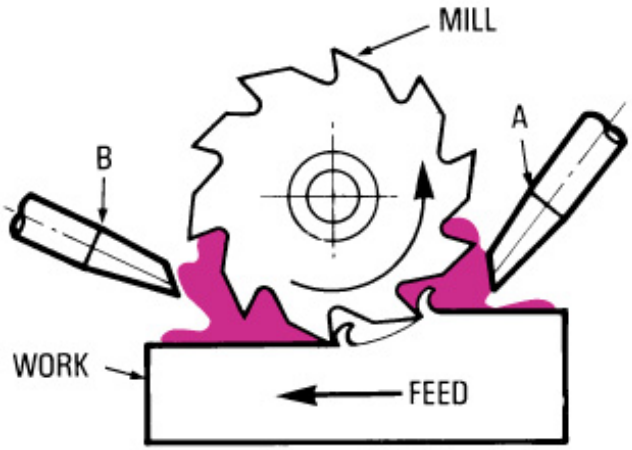


Drilling and Reaming



Milling

- Face milling
  - Ring-type distributor recommended to flood cutter completely
  - Keeps each tooth of cutter immersed in cutting fluid at all times
- Slab milling
  - Fluid directing to both sides of cutter by fan-shaped nozzles ¾ width of cutter



Grinding

- Cutting fluid cools work and keeps grinding wheel clean
  - Applied in large quantities; very little pressure
- Three types of grinding
  - Surface
  - Cylindrical
  - Internal

Three Methods of Surface Grinding

- Flood method (one most commonly used)
  - Steady flow of cutting fluid applied through nozzle.
- Through-the-wheel method
  - Coolant fed to special wheel flange and forced to periphery of wheel and to area of contact by centrifugal force
- Spray-mist system (most effective)
  - Compressed air passing through a T connection syphons small amount of coolant from reservoir and discharges it at chip-tool interface

Cylindrical and Internal Grinding

- Cylindrical grinding
  - Important entire contact area between wheel and work flooded with steady stream of clean, cool cutting fluid
- Internal grinding
  - Cutting fluid must flush chips and abrasive wheel particles out of hole being ground
  - As much fluid as possible should be applied

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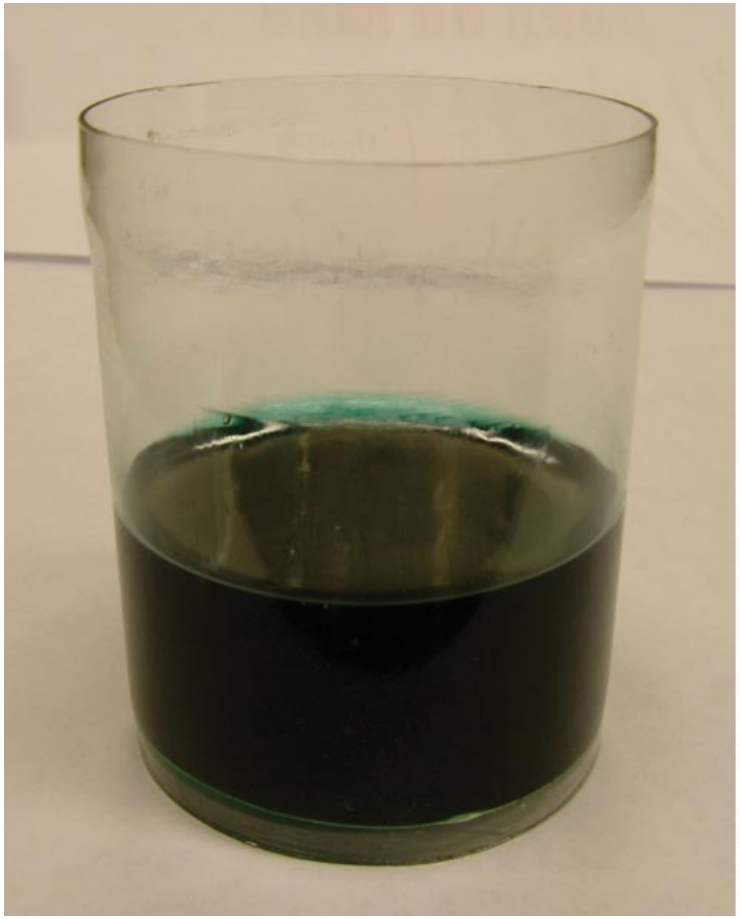

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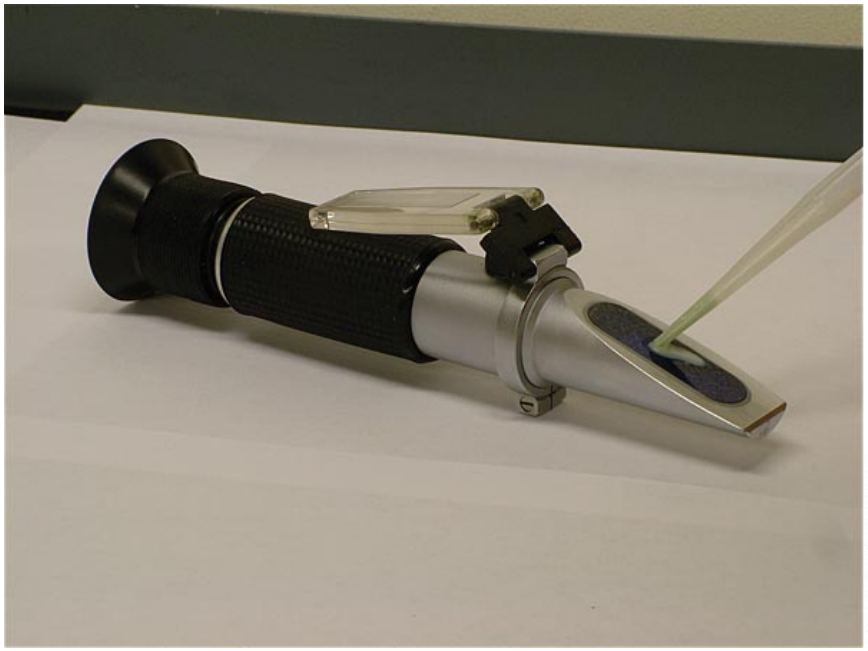

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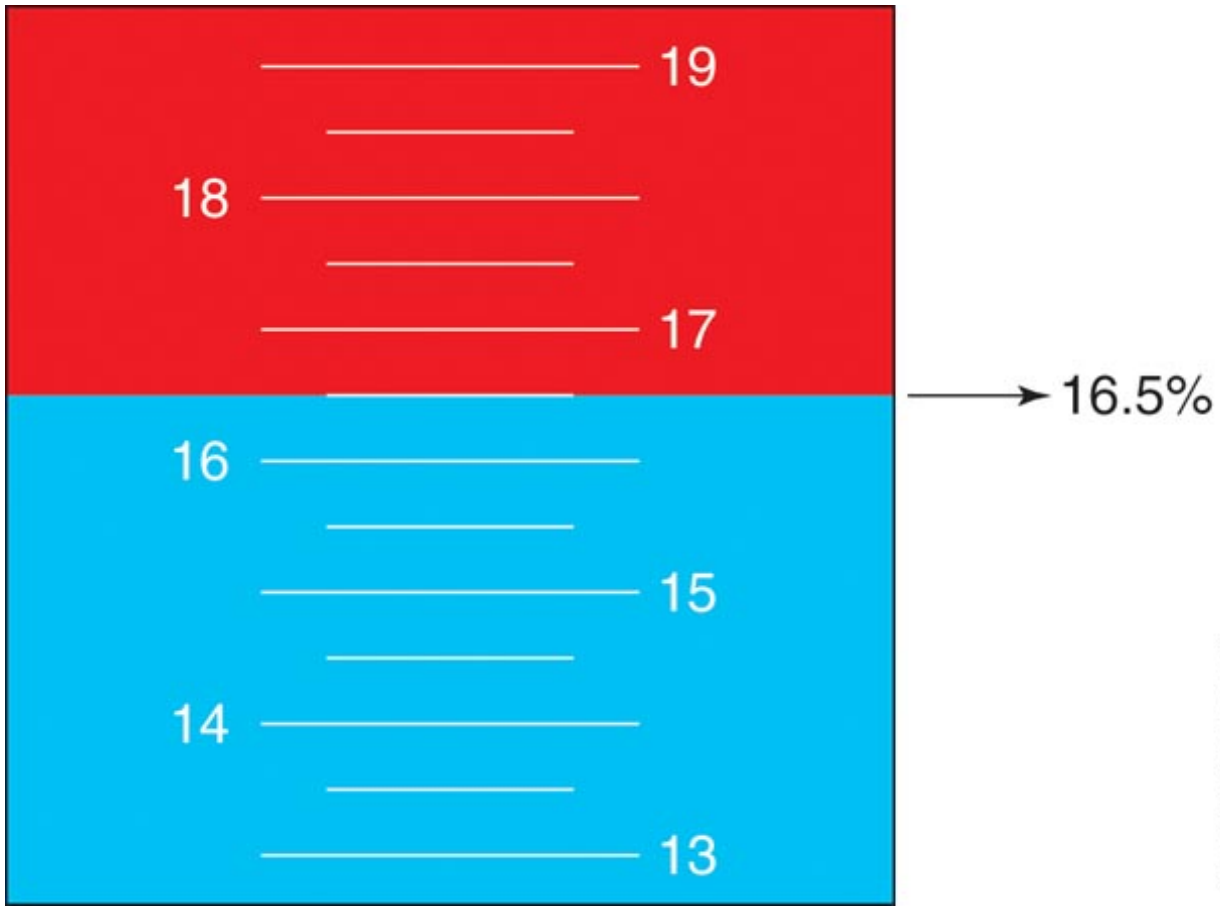

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